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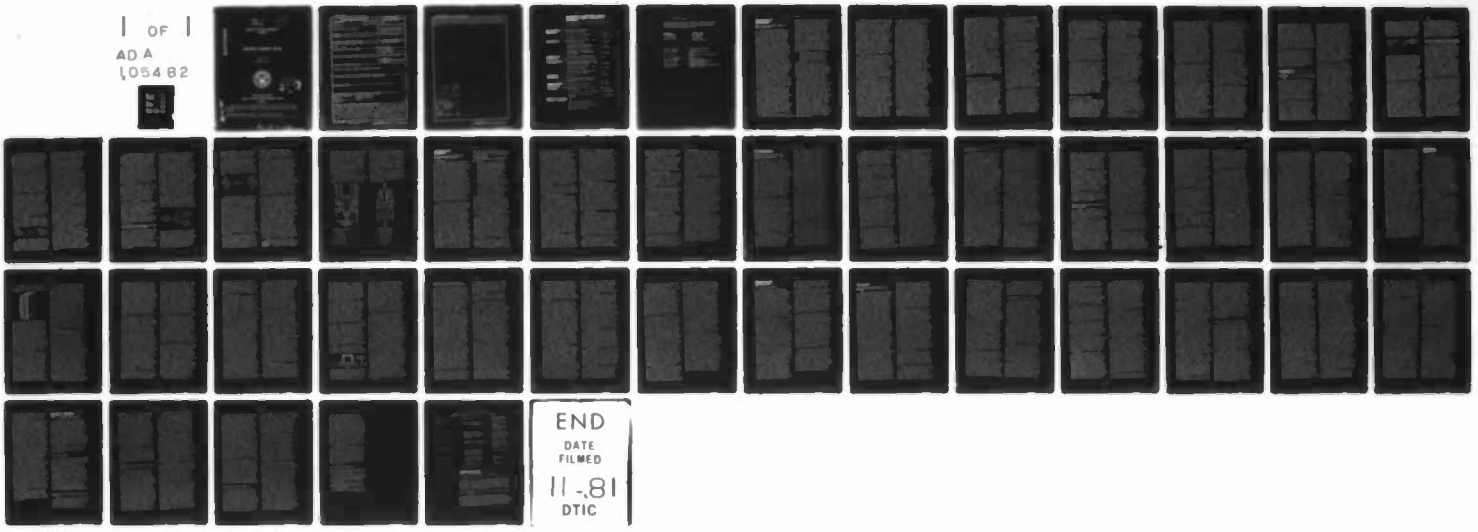

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This is a monthly publication presenting brief articles concerning recent developments in European Scientific Research. It is hoped that these articles (which do not constitute part of the Scientific Literature) may prove of value to American scientists by calling attention to current developments and to institutions and individuals engaged in these scientific efforts.

The articles are written primarily by members of the staff of ONRL and occasionally articles are prepared by, or in cooperation with, members of the

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LONDON

edited by Nicholas A. Bond, Jr. and Don J. Peters

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BEHAVIORAL SCIENCES

BOMB-DISPOSAL OPERATORS: WHAT'S SO SPECIAL ABOUT THEM?

The military has always had its share of disagreeable and dangerous jobs. But consider the daily work situation of a British Army bomb-disposal operator. First, of course, is the danger: suspected bombs frequently do explode, sometimes while the disposal crew is working on them. Then there is the uncertainty: many calls are indeed hoaxes and many "bombs" are duds, but one never knows. The actual business of deactivating an explosive device can require technical reasoning and careful motor-skill output. There are often extreme time pressures on the operator, too; he and his associates must "do something" to save the threatened people or the building, as the case may be, "right now." The police, political authorities, doctors, and bystanders may also offer advices and place pressures of various kinds on the operators. The relationship with the suspected object can be very personal: although there is a four-man disposal team, only the number-1 operator actually approaches the bomb. And the crises keep coming: if one threat is disposed of this morning, inevitably there will be another one very soon. During the worst days of the bombing campaign in Northern Ireland, an operator might deal with several genuine or suspected bombs a day. Sometimes a "disruption day" was designated by the terrorists, and there would be many calls. One Friday, it was announced that bombs had been placed in cars all over Belfast and that these were set to go off at 5 p.m.; in fact, several did explode at that hour.

For such extremely demanding work, surely it would be important to have the most rigorous selection program, right? Wrong. In the British Royal Army Ordnance Corps, any enlisted man or officer with the proper training and rank can volunteer for bomb-disposal duty in Northern Ireland. There is usually a psychiatric interview, and also a few weeks of special pre-duty training before the assignment. But almost nobody fails either the interview or the refresher course. Even though little positive selection takes place, it is possible to correlate various measures from the pre-duty period with the success of bomb-disposal operators in Northern Ireland.

Professor S.J. Rachman, of the Institute of Psychiatry at London's Maudesley Hospital, has been following a representative cohort of bomb-disposal operators who completed a tour of duty in Northern Ireland. Before being assigned to a 4-month hitch of such "combat" duty, all the men completed some personality inventories (Cattell's 16PF and Clinical Analysis Questionnaire). Other "predictors" available on each man were a psychiatrist's "suitability" rating on a four-point scale, the man's grade in a short preoperational course, and the usual personnel-folder biographical data. Two performance criteria were used: military decoration, and end-of-tour reports. Thirty-seven operators (nearly 30%) won decorations, and 8 of these received the highest award and thus were "George Medallists." An excerpt from an official citation gives some flavor of the kinds of behavior observed:

> ". . . after using the disruptive equipment he re-entered the restaurant to find that the clock delay had restarted and was within one minute of making contact and detonating the bomb; he speedily cut out detonator and bomb."

The end-of-tour reports were written by an officer who had been in close contact with the operator's work. These original reports were then scored by two other experienced Royal Ordnance officers back in England. The reports were originally sorted into five "quality" categories; these five were finally collapsed into three because the extremes were not often used. There was good agreement between scorers.

The end-of-tour ratings did not correlate strongly with any of the predictors, and in general the decorated operators resembled the nondecorated soldiers quite closely on the test and biographical variables. One small surprise was the extremely low hypochondriacal (H) scores in the decorated group. The decorated returnees scored significantly lower (more favorably) than a comparison random sample; in fact, seven of the eight George medallists had scores of 1, the lowest possible on this measure. These brave and competent men, then, say that they feel extraordinarily fit and happy. Since in other military samples, low H has been related to ego-strength, and (inversely) to the likelihood of incurring the hyperventilation syndrome, there is reason to think that the decorated operators also rate highly on the positive self-image distribution—even more highly than the other competent operators in the nondecorated comparison cohort (N=52).

Rachman's analyses reveal some other factors that may be operating in the bomb-disposal personnel picture. A significant fraction of the enlisted operators, it turned out, came up through a Royal Ordnance Corps "military apprenticeship"; under that regime, a boy enters the service at 15 or 16 years of age. By the time he is in his early twenties and ready for bomb duty, he will be a corporal or sergeant, and will have some years of training and soldiering behind him. Such people are probably more committed to the service, and to their ordnance branch, than are the usual recruits. It was also found that a larger-than-expected proportion of the bomb-disposal operators came from military families, which suggests approval of an Army career. (In recent West German studies, acceptance of military life by spouse or girlfriend was one of the most powerful predictors of voluntary enlistment; see ONRL C-3-81.)

All of the bomb-disposal operators are highly trained, and they perceive themselves as such. The advanced courses stress the technical part of the job and emphasize the importance of a matter-of-fact, technical frame-of-mind in doing the work calmly and efficiently. Old hands encourage the novice operator to think of himself as the cool professional in a complex, emotional, and threatening situation. The trainee is told: none of the other people who are there can be expected to show the proper calmness, rationality, and competence; and you, as the bomb-disposal operator, must quickly take control.

This extraordinary coolness "under fire" was confirmed in an interesting way in Rachman's laboratory. Three sample groups of people had to work on a very difficult and frustrating discrimination task, and their heartbeat rates were monitored continuously during the performance. The subjects included a grab-sample control group of civilian hospital staff, a group of experienced but nondecorated bomb-disposal operators with at least one Northern Ireland tour, and a group of decorated bomb-disposal operators. The experienced operators had lower median heartbeat rates on the frustrating task than the civilians did (about 75 beats per minute compared to 82); but the decorated group had still lower heartbeat rates (about 71 per minute), and their rates rarely changed, even during the most difficult parts of the experiment. As Rachman well recognizes, there are only small numbers of subjects in this research, but the trends in the data make sense: bomb-disposal people, and especially those who have been decorated for gallantry, can control their physiological reactions to anxiety and frustration.

Though sociometric records from Northern Ireland are not available, from all reports, bomb-disposal operators were highly interactive with, and supportive of, other members of their teams. This enduring base of helpful "others" can be an important factor in maintaining performance. US studies by Professor Irwin Sarason (Univ. of Washington) showed that men receiving early discharges from the Navy (mostly for AWOL infractions) were apt to be those who had many negative life changes and few social supports. The effects of "psychosocial assets" have been demonstrated at all age levels: babies, adolescents, and adults benefit from an environment in which they have the support of family and friends. One investigator, who followed the records of Harvard undergraduates over a 30-year period, found that positive adult adjustment was correlated with a supportive family adjustment from many years earlier.

A reasonable conjecture, then, is that positive social support can be experienced and encouraged in the military, and that bomb-disposal people are very high on that variable. But the conditions of military life can dissipate social support, too. An analysis of early dischargees from the US Army in Germany gives an indirect documentation of this. When Manning and Ingraham (US Army Medical Research Unit, Heidelberg) checked a large sample (N=649) of early US Army dischargees, they found that these "marginal" soldiers often experienced the highest self-esteem, and had the most positive attitudes toward the military, right after completing basic training. Presumably this was because of the successful struggle to get through "basic," as part of a small and stable group of people who shared the same problems. At just the point when basic training is completed, however, it is standard military practice for the group of trainees to be broken up, and for each person to be sent to a new location. In a difficult new environment, such as barracks life in West Germany, a great majority will be successful in setting up new systems of support, but some will not be able to do so.

As in most studies of exotic work environments, some interesting minor findings came out of Rachman's work. Regular infantry soldiers in Northern Ireland, for instance, say they absolutely would refuse bomb-disposal duty;

and bomb-disposal operators are equally adamant in their rejection of regular infantry patrol duties. (Statistically, patrol is more hazardous). A sizeable fraction of operators, including some decorated ones, have standard phobic fears of heights, dentists, and snakes. Some of the areas in Northern Ireland are nearly free of bomb incidents; these "dull" areas however, are not preferred by the bomb-disposal operators. When these soldiers return to England after a 4-month tour, there is a strong tendency toward change in marital relationships; about half the changes are for the better, and half are for the worse. A positive note: there are almost never any "breakdowns" on the job, or after returning home. This finding accords well with a technical-expertise-plus-social-support interpretation of effective performance.

Perhaps the evidence is not yet solid enough to justify the selection of new recruits on the basis of "soft" variables such as early-life and recent social support, life-change history, and a vigorous self-image. But the British bomb-disposal-operator research is certainly an interesting part of that accumulating evidence. And it gives reason to hold the optimistic hypothesis: rather "ordinary" military people, if they are given hard technical training that they can master, and if they operate with suitable personal and occupational social support, can accomplish the most extraordinary tasks. (Nicholas A. Bond, Jr.)

IONIZED AIR AND VDU OPERATORS

The proportion of "free ions" in the air varies widely as a function of the environment. Thus, "clean outdoor air" may have something like 1,000 positive and 1,000 negative "small ions" (those with a mobility in a field of about 1-2 cm/sec/volt/cm) per cc of air; "polluted" or city air probably would have fewer ions. Indoor air, say in an air-conditioned office, might have still fewer ions, on the order of 100 or so, per cc of air. There are commercial "ion generators" that can change indoor ion levels rather drastically; these devices operate via a corona-discharge "ionizer" and a fan. If a sufficiently high negative voltage is applied to a needle point, both positive and negative ions are generated at the needle source. The negative ions are repelled, and thus free to be blown about the area. Since some studies have indicated that "small" negative ions may be of biological benefit, the commercial devices are designed to raise the negative ion levels.

The behavioral question, of course, is whether ion levels cause any discernible difference in human performance, or in workplace comfort and satisfaction. This question becomes particularly interesting in an office environment like a computer center, where there are many visual display units (VDUs) in the area. Video display screens usually have positive voltages, and as a result the negative-ion count near the screen may be nearly zero. In fact, actual measurements show this to be the case.

Dr. L.H. Hawkins, from the Human Biology and Health Department of the University of Surrey (UK), recently reported two types of data on ionization effects. His presentation was given on 2 July 1981, at a Loughborough University of Technology symposium on "Health Hazards of VDUs." In one set of studies, Hawkins maintained a small environmental chamber at relatively high and stable levels of negative ions, for part of the time, and kept it under a positive-ion situation the rest of the time. Subjects had to perform standard tasks, but were unaware of ion manipulation. Under a negative-ion ambience, gains on the order of 25% over baseline were observed for mirror drawing and rotary pursuit; for visual and auditory reaction time, the negative-ion enhancement was smaller (about 6%), but it still was statistically significant. In general, the more complex tasks seemed to benefit more than did the simpler ones. There were also suggestions in the data that females are more ion sensitive than are males, and that the effects are temperature and humidity dependent. High humidity and high temperature both tend to wash out the effects.

To develop the second type of data, Hawkins installed two commercial ion generators (Medion EC300) in a rather congested computer office. The generators had an experimental advantage: the fan unit could be switched on separately from the ionizer unit, and with the fan running all the time the people working in the office did not know when the ionizer was working. When it was operating, there was a mean level of about 3,500 negative and 100 positive ions/cc of air; when it was shut off, the air in the office showed an average of about 550 negative and 500 positive ions/cc.

There were 54 people (4 females) who worked 3 shifts in the office. At the end of each shift, each worker filled out a short questionnaire; among the items rated were the environment (too hot, too cold, comfortable, pleasant, etc.), "how I felt today" (drowsy, alert, etc.), headache (severity, if a positive answer), sleepiness, and nausea. In general, Hawkins found that people felt colder and more uncomfortable on the later shifts, and they also reported more headaches then.

Negative ions apparently produced some positive effects. Headache complaints occurred in only 6% of the shifts during which the ionizer was operating, whereas they were mentioned in about 26% of the shifts in which it was turned off. Similar improvements were observed with respect to nausea, dizziness, and worker ratings of pleasantness. Since some computer office people stay close to VDU screens during their work, and since negative-ion levels are so depleted there, a possible accessory to a VDU might be an ionizing attachment.

The effects of ionized air on performance are often difficult to replicate. And since negative ions are known to be chemically reactive, it is possible that the effects could be deleterious. In reporting this work, Hawkins was careful to point out the tentative nature of the findings, and he also noted the many other factors than can influence an individual's work satisfaction. Intrinsic work satisfaction or supervisory climate, for instance, might be far more important than the level of ionization in the air. If the risk and control problems can be handled, perhaps the best settings for practical military experimentation in this area would be those that resemble Hawkins's office situation; that is, where people are doing routine shift work in a rather crowded computer-console environment. (Nicholas A. Bond, Jr.)

SUBSTITUTES FOR IQ SCORES

Criticisms of IQ measurements come from many quarters. It is alleged that the test scores are "only verbal"; they are "too schoolish"; they are due mainly to environmental advantages; they are based on arbitrary item sets; they can be improved by coaching; they do not really determine success in the real world; they are biased against many groups of people; and so on. When a famous American school test recently was discovered to have one or two questionably-keyed items (out of 100 or so), the resulting lawsuit received international publicity. Antitesting sentiment may be noticed in other domains as well. For instance, there are now lawsuits questioning the validity of bar examinations for lawyers, with some of these suits being brought by people who completed the law school curriculum but failed the bar examinations several times.

Some time ago, the Dutch Army began to question the use of IQ-type test scores for military selection—not because of the technical difficulties mentioned above, but because the scores simply did not contribute much to performance prediction. Dr. Menno Harveld of The Netherlands' Ministry of Defense developed this argument in May 1981, during the 17th International Symposium on Applied Military Psychology, which met in Portugal (see ONRL C-3-81). Suppose there are six categories of human capability, as measured by the tests, with a highest and lowest class, each including 10% of the subjects, and four intermediate classes consisting of 20% each. According to elementary information theory, when the battery of tests is given and persons are assigned to one of these six categories, there should be realized about 2.52 bits of information per assignment from the testing process. In fact, for some of the categories, essentially all of this information is provided by considering only the educational level of the individuals, with the IQ-like test scores providing only about 0.2 bits of information per classification, overall.

Harveld gives a straightforward interpretation of these results. In a democratic society with free educational opportunities, people tend to gravitate toward the educational level that accords with their maximum capabilities. Thus, educational level itself encapsulates much test information about the person: there are very few graduate geologists or computer programmers who do not have top-category reasoning and quantitative scores. Analysis of the information realized from tests, then, often yields the conclusion that background variables are informative enough by themselves; and these entries can be obtained directly from the personnel records. One exception may be noted: tests may contribute some useful information in the lower educational levels.

At Edinburgh University, Prof. Chris Brand and his associates have been working with indicators of "mental

speed," and their experimental procedures conceivably could be used for individual prediction and assignment. There are two task setups, one visual and one auditory. For visual work, subjects are first screened for Snellen acuity (visual acuity). They are then seated in front of a display, where they have to decide which of two lines is longer after seeing the display for very short exposures. The display is a plain white card containing two straight lines, one 7.5 cm long and one 5.1 cm long, which are 2.4 cm apart and connected at the top with a straight line. When a trial begins, a "masking" card is first shown to the subject; this appears as a mat of thick black lines which obliterates the (later) target material. There is a small "attentional dot" in the middle of the mask, and the subject is directed to look at this spot. Then the two-line stimulus card is briefly presented, and the subject says "left" or "right," to indicate which line is the longer. The mask is immediately reapplied after the controlled exposure, presumably to preclude further processing of the target display.

Subjects are practiced to a criterion of twelve consecutive correct calls at a duration of 130 msec (230 msec for retarded subjects); after this, blocks of 20 trials are administered, with the usual controls for order effects. The duration of exposure is systematically reduced, and IT (Inspection Time) is taken as the shortest time level at which a subject achieves 95% correct calls for that level and for all longer durations. Total testing time is an hour or less per subject.

A logically similar "tachistophone" setup is used for auditory stimulus presentations. Square-wave tone sequences (770 Hz and 880 Hz in random order) are presented successively via earphone to the ear preferred by the subject, and the subject has to discriminate whether the order is low-high or high-low. Tone durations are adjusted downward until the minimum time is reached in which the subject scores 11 correct out of 12 presentations; this is the Auditory IT. Auditory ITs can vary widely among individuals: in the Edinburgh sample, they ranged from 6 msec to 160 msec. Within subjects and testing occasions, however, they appear to be quite reliable; once a subject's IT is known, then stimulus pairs presented for only a few milliseconds longer are identified in a nearly error-free manner.

Visual IT has substantial correlations with scores from other types of tests such as Cattell's Culture Fair, the Wechsler Adult Intelligence Scale (WAIS) IQ, and Raven Matrices; correlations (r's) on the order of 0.7 or higher have been obtained by experimenters in Europe and Australia. Even though some of the research samples employed have unusually high IQ variances, thereby accentuating correlations of any measures in that sample, these results are impressive; and when corrected for variance the correlations are still in the 0.6 range. Only one study with auditory IT has been done, but here again correlations of about 0.7 were observed with Raven Matrices and with vocabulary. Visual IT has the expected covariance with other mental speed measures such as choice-reaction time, and in one pilot study, it correlated almost perfectly with auditory IT.

The IT-IQ relation seems to be attenuated when the stimuli are more complex. Thus, when child subjects had to identify pictures of animals on short exposure, IT-IQ correlations were lower than when only the names of animals had to be discriminated. Also, the preliminary data indicate that IT-IQ associations are higher when exposure times are less than 250 msec. Brand thinks that the person with high IQ may show his (her) advantages most clearly when the task is "reduced" and extremely clear cut. IT measurements certainly seem to be culturally fair and to be determined in a straightforward way, at least in the visual mode. They may be good candidates for "norming" or standardization in large cohorts of people. Also, much more information is needed on the modifiability of these performances through practice.

At the University of London's Institute of Psychiatry, Drs. Elaine Hendrickson and Alan Hendrickson have found that a suitable measure of EEG waveforms is the total of the lengths of the line segments of the waveform over a standard observation interval. This measure is then correlated with IQ. Their subjects were presented with a standardized loud stimulus (1000 Hz sine wave, 30 msec duration) via binaural earphones. EEG data were sampled at 0.5 msec intervals; records were edited to remove gross artifacts of muscular or eye movement. The length of the final EEG waveform over a 500-msec epoch was measured for each subject by a straightforward manual process. The outcome of all the measurement operations was an average length for each subject. Pearson r was 0.47 between average

waveform length and score on the Raven Advanced Matrices (RAM). Since it was known that the student selection had been based in part on RAM scores, the range was probably attenuated; when corrected for attenuation, the estimated "true" r was 0.80. In a just-completed study, Dr. Hendrickson used her EEG waveform measure (computed by piece-wise linear methods) on a sample of 200 typical fifth-form London school children (aged 14 and 15). Correlations with Wechsler IQ were again very high, in the 0.7 range; in fact, when mean and variance indexes were combined for a multiple correlation coefficient r, the correlations approached the reliability of the Wechsler test scores.

There are plenty of unresolved questions remaining; Brand's IT seems to discriminate better in lower IQ subjects, whereas the Hendrickson EEG measure may be better suited to high-IQ samples. And it would be interesting to know how their measure is associated with age, with more creative kinds of mental products, and with other aspects of intelligence, such as the "componential" units identified by Robert Sternberg. (Nicholas A. Bond, Jr.)

CHEMISTRY

EXPERIMENTS WITH OPTICALLY ACTIVE POLYMERS IN UTRECHT

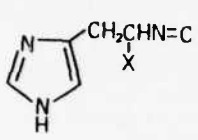
The town of Utrecht lies a few miles south of Amsterdam on a branch of the Rhine River. At the University of Utrecht, which was founded in 1636, I visited Prof. Wiendelt Drenth in the Department of Organic Chemistry. Drenth and his co-workers have recently been involved in an investigation of a fascinating type of linear polymer which exists as a helix. As a result of this structure, these polymers are optically active and may show interesting enantioselective catalytic activity when employed as a polymer backbone for polymer-bound reagents.

These compounds are obtained by a metal-catalyzed polymerization of isocyanides. The primary structure of these polymers is that of a poly(Schiff base) $[R\text{-}N{=}C<]_n$. In a typical procedure of Drenth's, a 2 molar solution of the isocyanide in methanol is treated with 1 mol % of $NiCl_2 \cdot 6H_2O$ at ambient temperature. Polymers made in this way have molecular weights of 40-60,000, although in the absence of solvent, molecular weights of 150,000 have been obtained. Several years ago F. Millich (Univ. of Missouri-Kansas City) proposed that these polymers have a rigid-rod, helical structure and that consequently they should be chiral. Drenth and his co-workers have been able to confirm this structure for these polymers with the resolution of a tert-butyl isocyanide oligomer into fractions with (+) and (-) signs of optical rotation. Using the IUPAC rules for nomenclature for single-strained organic polymers, Drenth prefers to call these polymers not by the more obvious name of poly(isocyanides), but rather by the correct name of poly(iminomethylenes). These polymers show only weak absorptions in the UV and visible spectrum. In contrast, the isomeric polymers of cyanides known as poly(azaethenylenes) $[\text{-}C(R){=}N\text{-}]_n$ exhibit entirely different properties, being black in color, semiconducting, and planar in structure. Drenth has found that poly(iminomethylenes) derived from primary alkyl isocyanides can be converted to the corresponding poly(azaethenylenes) with a trace of acid.

Drenth has proposed a mechanism for the polymerization of isocyanides by nickel(II) chloride. It involves a circular sequence of insertion reactions around the nickel center (a so-called "merry-go-round" mechanism), starting with the square planar complex, $Ni(CNR)_4^{2+}$. Under achiral polymerization conditions, equal amounts of right and left helices of the polymer are apparently formed. However, Drenth has found that when an isocyanide is used which contains a chiral R group, polymerization results in preferential formation of one of the screw senses. Knowing the absolute configuration of the R group, the merry-go-round mechanism allows a prediction of the preferred helix. Drenth's group has attempted to employ optically active nickel catalysts to induce an enantioselective polymerization of achiral isocyanides, but as yet without success.

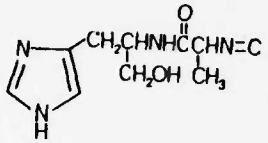
A principal area of interest for Drenth at present is the use of functionalized poly(iminomethylenes) as catalysts. In particular, his group is investigating the activity, as hydrolysis catalysts, of polymers which contain imidazole groups in the side chain R. Drenth feels that these studies may provide insight into the catalytic action of imidazole groups in hydrolytic enzymes. Further, because of the chiral nature of the rigid rod structure of the polymer, these catalysts may be able to mimic the enantiospecific action of enzymes. The initial studies have been directed at the catalytic activity of poly(iminomethylenes) towards achiral

activated esters. Interesting results have been obtained from a study of the catalyzed hydrolysis of 4-nitro- and 2,4-dinitrophenyl acetate with two polymers that Drenth refers to as: poly(carbylhistidine) and poly(carbylhistamine) derived from the monomers, 3-(4-imidazolyl)-2-isocyanopropanoic acid (*1*) and 2-(4-imidazolyl)-1-isocyanoethane(*2*). A kinetic analysis of the hydrolysis



1, X = CO_2H

2, X = H



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reactions has indicated that the initial step is the acylation of the imidazole group with a slower subsequent deacylation. In the presence of excess ester the system exhibits burst kinetic behavior. Of most interest is the finding that the polymeric matrix derived from *1* exhibits 400 times greater activity than histidine itself, with 6 times greater activity obtained from the polymer of *2* compared to the imidazole group of histamine. Drenth explains these rate enhancements in terms of a cooperative effect of the imidazole and carboxylic acid functions for the first polymer, and between neighboring imidazole groups on the polymer backbone for the second polymer.

Drenth's group is now working on the possible use of these optically active polymers in enantioselective hydrolysis of chiral esters. They have observed that the polymerization of a chiral isocyanide results in polymers that have predominantly one screw sense. The most encouraging results have been obtained with poly(D-carbylalanyl-L-histidinol) derived from isocyanide *3*. This catalyst shows enantioselectivity in the hydrolysis of p-nitrophenyl esters of D- and L-amino acids, $k_L/k_D = 1.1$. Drenth believes that this is the first example of enantioselective catalysis by imidazole anchored to a synthetic polymer support. He has also found that the selectivity does not significantly depend on the structure of the chiral ester nor on the pH of the reaction medium. As enantioselective catalysis by soluble linear dipeptides has not been observed to date, Drenth feels that his selective catalysis is an effect of the helical structure of the poly(iminomethylene) backbone rather than the chiral group of the isocyanide.

Although the work on catalysis with these optically active polymers is only in the initial stages, it seems clear that these types of polymers may have interesting and useful catalytic properties. We can anticipate significant new results in the near future from Drenth's group. (A. Paul Schaap)

INTERNATIONAL SEMINAR ON THE ACTIVATION OF CO_2 AND HETEROALLENES ON METAL CENTERS

The International Seminar on the Activation of CO_2 and Heteroallenes on Metal Centers was held in Rennes, France, during the week of 18 May 1981. The meeting, which took place at the Laboratory for Organometallic Chemistry, University of Rennes I, was organized by Profs P. Dixneuf (Univ. of Rennes I) and R. Adams (Yale Univ.). Because the number of participants was limited to a small group of experts, the discussions were vigorous and well focused. In this article, a number of the papers delivered at the seminar are summarized in several categories: the structure of CO_2-metal complexes; insertion reactions of CO_2 into metal-carbon, metal-nitrogen and other bonds; the catalytic reduction of CO_2; and the electrochemisty of CO_2. Other papers were also presented which treated various non-CO_2 heteroallenes such as CS_2, COS, HN=C=NH, and NCO^-.

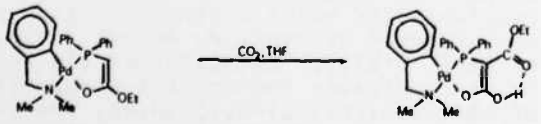
Structural chemistry coupled with synthesis has much to offer in the field of CO_2 chemistry. Detailed structural information obtained via X-ray crystallography is important in providing models for metal catalyst/CO_2 interactions. These data, coupled with the systematic synthesis of CO_2 complexes, can provide a guide for the type of CO_2-catalyst interactions which can facilitate reduction. Little is known of CO_2-metal complex structures. One of the two CO_2 complexes for which a structure is known was prepared by Prof. M. Aresta (Univ. of Bari, Italy). He discussed his work on the synthesis and crystal structure of $[Ni(CO_2)(PCy_3)_2]\cdot 0.75C_6H_5Me$, where Cy=cyclohexyl. Aresta has recently prepared another complex, $RhCl(CO_2)_2(PEtPh_2)_3$, which is unstable in vacuum. After a year of effort, he has not succeeded in obtaining crystals suitable for an X-ray crystal structure. He has also prepared a third complex, $Rh(diphos)(CO_2)BPh_4$, but again, he has not yet characterized this complex structurally.

Prof. Kenneth Nicholas (Boston College) described results he obtained recently relating to the crystal structure of $Rh(Ph_3P)_3H(CO_2H)$, which was prepared from the reaction of a dihydrido tetraphosphine rhodium complex with CO_2. A formate group which results from the insertion of CO_2 into the Rh-H bond is found to be coordinated to the metal through the two oxygen atoms.

A number of papers dealt with CO_2 insertion reactions, i.e., the reactions of CO_2 with an X-Y bond giving rise to an XCO_2Y group. Prof. Malcolm Chisholm (Indiana Univ.) discussed his work on the synthesis of carbonate and carbonic ester complexes of tungsten and molybdenum through the reaction of CO_2 with dimethylamino and with methoxo compounds. The crystal structure of one of those complexes, $W(NMe_2)_3(O_2CNMe_2)_3$, was determined and the compound was found to be the facial isomer. Interestingly, this tris-complex undergoes rapid exchange of free and carbamate CO_2 in solution. In contrast, dimethyl amine does not exchange with the complexed dimethylamido groups.

Prof. Daniele Gervais (CNRS Coordination Chemistry Laboratory, Toulouse) spoke about the insertion of CO_2 into titanium-nitrogen and titanium-oxygen bonds. As an example, she found that tris(dialkylamido) titanium(III) compounds readily insert CO_2 to give the corresponding carbamate complexes. More importantly, the reaction of CO_2 with $Ti_4(OEt)_{13}H$ to give $Ti_4(OEt)_{13}(CO_2)H$ was reported; this complex was quite stable. These results point the way to the examination of the CO_2 chemistry of a wide range of alkoxo/oxo metal clusters with a view to synthesis, structure, and catalyst modeling.

Dr. P. Braunstein (Louis Pasteur Univ., Strasbourg) studied the insertion of CO_2, as shown in the reaction below. The facile reaction is taken as evidence for the nucleophilic character of the incipient carbanion adjacent to phosphorous.



Dr. Jan E. Bäckvall (Royal Inst. of Technology, Stockholm) talked about his work on the sterochemistry and mechanism of metal-catalyzed insertion of CO_2 into epoxides. This research was pertinent to the industrial use of CO_2 and epoxides to produce organic carbonates. Bäckvall utilized bis(phosphine)nickel and other complex catalysts to effect the addition of CO_2 to epoxides. Depending on the conditions, sterospecific opening of the epoxide ring could be effected.

Prof. P. W. Jolly (Max-Planck-Inst. for Coal Research, Mulheim-Ruhr) had a paper on the reactions of CO_2 with organo-nickel and organo-palladium complexes. Representative of this work was the reaction of CO_2 with bis(2-methyl-π-allyl) nickel in the presence of a triallylphosphine. A crystal structure of one of the products was obtained which showed that CO_2 had inserted in the metal-carbon bond and that a phosphine moiety had become coordinated to nickel. Analogous chemistry was found for Pd and Pt.

Electrochemical reduction of CO_2 offers a potential route to CO_2 containing species with high reactivity, for example, free radicals. Two papers dealt with the electrochemistry of CO_2. Prof. Jean-Michel Saveant (Univ. of Paris VII) discussed the electrochemical reduction of CO_2. He noted that there is a strong solvent dependence for the reaction products. Bicarbonate is the exclusive product of reduction in water, while in propylene carbonate, oxylate and carbonate are obtained. A mechanism for the reduction process was proposed to explain the contrasting results in protic and aprotic solvents, and especially the formation of a carbon-carbon bond in the latter case.

Prof. Richard Eisenberg (Univ. of Rochester) spoke on an indirect electrochemical approach to the reduction of CO_2. He called attention to the large overpotential for direct electrochemical reduction of CO_2. His approach to the diminution of this effect involves the mediation of the reduction of CO_2 by transition-metal macrocyclic complexes. Preliminary results were presented in which the use of a cobalt macrocycle led to the catalytic reduction of CO_2 (7-17 turnovers) in dimethylsulfoxide in the presence of water.

The thermal catalytic reduction of CO_2 is the traditional method of CO_2 reduction. Three papers were devoted to this process. Prof. Roger Kieffer (Louis Pasteur Univ., Strasbourg) compared the activity of CO_2/H_2 with respect to reduction utilizing rare earth copper-zinc oxides at high pressure. Although the product yield was relatively low with these catalysts, good selectivity characterized certain of the rare earth copper-zinc oxides: methanol of 98% purity could be obtained (300°C). Kieffer also discussed the mechanism for formation of C-H bonds during the reduction process.

Dr. Raymond Sneedon (Inst. of Catalysis Research, Villeurbanne) presented a paper on the hydrogenation of carbon dioxide at low pressures. His studies utilizing a Ni/MgO catalyst showed that CO_2 can be reduced at lower temperatures than CO and that the reduction of CO_2 is independent of the pressure of CO.

Prof. George Blyholder (Univ. of Arkansas) spoke on the activation of CO_2 on a manganese surface. His research utilized infrared spectroscopy to identify species on the metal surface. The model compounds Blyholder used led him to conclude that CO_2 was found as CO_3^{2-} under the conditions of the experiment. By surface chemistry standards, relatively high pressure was used (10^{-6} torr). The metal was deposited from a filament into a hydrocarbon oil on the surface of salt plates.

Two presentations were made on the synthesis of CO_2 complexes. Prof. James Ibers (Northwestern Univ.) described the preparation of a formate complex, $Rh(PPh_3)_2(CO)CO_2H$, from a dinitrogen starting material. The approach makes use of the facile displacement of N_2 by CO_2 to form the formate complex. A nickel and a platinum complex which may contain CO_2 also was reported. Further work is needed to elucidate the nature of these compounds.

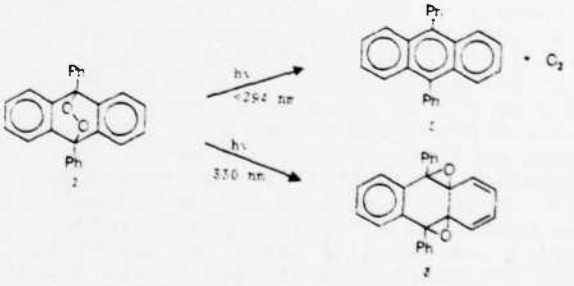
Dr. T. Herskowitz (E. I. Dupont de Nemours and Co., Wilmington) discussed the reaction of CO_2 with Ir(I) and Rh(I) compounds. The compound $Ir(dmpe)Cl \cdot CO_2$ (dmpe = bis(dimethylphosphinoethane)) has been obtained, along with others utilizing chelating phosphorus and arsenic ligands. While trends with regard to affinity for CO_2 were obtained (dimethyl > diethyl > dipropyl with the ligand $R_2PCH_2CH_2PR_2$), the structure of the new compounds and the manner in which CO_2 is bound remain unknown. (Kenneth J. Wynne, Office of Naval Research, Arlington, VA)

PHOTOCHEMISTRY AND HIGH PRESSURE STUDIES AT THE UNIVERSITY OF FRANKFURT

During the last several years, many German universities have moved from their center-city locations to the suburbs. In the case of the University of Frankfurt, new facilities have been built for the Institutes of Organic and Inorganic Chemistry (see *ESN* 33-12:500 [1979]) in the suburb of Niederursel. This building program, however, has been stopped for the present, with the result that the Institute of Physical Chemistry of the university remains in the center of Frankfurt.

At the institute, I visited Prof. Hans-Dieter Brauer and Prof. Hartwig Kelm. Brauer is a photochemist who is collaborating with Dr. Rheinhard Schmidt on several exciting areas of research. In particular, they have recently discovered a new photochromic system which shows considerable promise. Another major area of research for Brauer and Schmidt concerns the effects of high pressures on photophysical processes of organic substrates. In this area they collaborate with Kelm, who has been a leader in studies of reactions (principally inorganic systems) under high pressure. Brauer and Kelm share the high-pressure facilities, which include instruments for measuring the following properties under high pressure: fluorescence, absorbance, conductivity, and chemiluminescence. Although Kelm has recently accepted appointment as president of the university, he still maintains close contact with his research group at the institute. He is ably assisted by his colleague, Dr. Rudi van Eldik, who has recently come to Frankfurt from Potchefstroom University, South Africa.

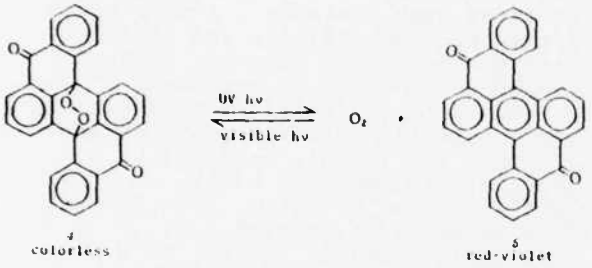
Brauer, Schmidt, and Dr. W. Drews have recently studied the wavelength-dependent photolysis of peroxides such as the endoperoxide *1* of 9,10-diphenylanthracene (*2*). They observed that the irradiation of endoperoxide *1* at wavelengths less than 294 nm in the region of the π,π^* absorption of *1* ($S_0 \rightarrow S_2$ transition) results in a concerted, adiabatic



reaction with the formation of equimolar amounts of the anthracene *2* and electronically excited, singlet molecular oxygen. The quantum yield for this photoextrusion process is 0.28. In contrast, irradiation at lower energies (330 nm) and excitation of the $S_0 \rightarrow S_1$ transition gives dramatically diminished quantum yields (0.009) for the formation of *2*. This lower energy band is associated with the π^*,o^* transition of the

peroxide chromophore. At the longer wavelength, a photolytic biradical cleavage of the peroxide bridge occurs, which yields the unstable diepoxide *3* with a quantum yield of 0.07.

In a related study, Brauer has investigated the photolysis of endoperoxide *4* derived from heterocoerdianthrone (*5*). Peroxide *4* also exhibits wavelength-dependent photoreactions, with an irreversible decomposition to as yet unidentified products from either the S_1 (n,π^*) state or the T_1 (n,π^*) state. However, reversible cleavage of *4* to *5* and singlet molecular oxygen occurs from the S_2 (π,π^*) state.



Brauer indicated that *4* and related endoperoxides may provide the basis for new photochromic systems. These would be based on the photoreversible addition of singlet oxygen to aromatic hydrocarbons such as *5*. The colored component of the system is the red-violet heterocoerdianthrone (*5*) while the colorless component is the endoperoxide *4*. Self-sensitized photooxygenation of *5* using visible light of wavelengths greater than 578 nm yields *4*. UV irradiation of *4* at 313 nm regenerates the parent hydrocarbon *5* and oxygen with a quantum yield of 0.26. As quantum yields for competing, irreversible side reactions are extremely small (0.004 at 313 nm), the number of reversible photochromic cycles can be quite high. In addition, both components are thermally very stable with a calculated half-life of 1,000 years for the peroxide at 293 K. This group is continuing its work in this area and has recently developed a system which shows blue to colorless photochromic properties.

Another area of study for Brauer's group has been the photooxygenation of aromatic hydrocarbons. Solvent effects have been determined for the self-sensitized photooxygenation of rubrene and heterocoerdianthrone. In addition, relative fluorescence quantum yields, lifetimes of fluorescence, and rate constants for the quenching of fluorescence by oxygen have been established. The results indicate that singlet oxygen is generated by energy-transfer to oxygen from both the excited singlet state and the lowest triplet state of the hydrocarbon.

Brauer, Kelm, and Schmidt have collaborated on a detailed analysis of the indirect chemiluminescence produced by solutions of tetramethyl-1,2-dioxetane and fluorescent hydrocarbons such as 9,10-dibromoanthracene. The chemiluminescence has been studied as a function of the concentration of the fluorescer and of the hydrostatic pressure. It has been shown that energy transfer from triplet excited acetone, formed by the decomposition of dioxetane, to the fluorescer occurs by a spin-allowed TT transfer. Recent research in this area has employed an interesting technique using polyvinyl chloride (PVC) polymer films. The dioxetane and a fluorescent hydrocarbon are dissolved in tetrahydrofuran solvent, along with the PVC polymer. Evaporation of the solvent at ambient temperature provides a polymer film with a known concentration of dioxetane and fluorescer. Studies of the chemiluminescence from the film are then carried out at variable temperatures.

Drs. van Eldik, Kelm, and R. Doss have recently constructed a high-pressure, temperature-jump apparatus which employs an electric discharge through a solution to induce rapid temperature changes. This instrument was designed to study fast reactions in solution at pressures up to 2 kbar (approximately 2,000 atmospheres) and includes several significant improvements over instruments constructed in other laboratories. In particular, major changes have been made in the inner reaction cell. A schematic diagram of this instrument is shown on page 297. van Eldik indicated several of the important features of this instrument: a liquid pressurizing medium, a teflon-membrane, pressure-transmitting device, and a fixed electrode distance which does not vary with pressure. Using electrical discharges of 20 kV, temperature jumps of 3 K are obtained with heating times of 10-20 μs. This instrument has been tested with several well-characterized chemical systems in order to evaluate its performance. Activation volumes for fast substitution reactions for complex ions of first-row transition metals are now being studied with this new facility.

Kelm's group has studied a wide variety of inorganic reactions in aqueous solution using various high-pressure techniques. For example, Kelm, van Eldik, and Dr. P.A. Palmer, a former co-worker

who is now at the Argonne National Laboratory, have investigated the effects of pressures up to 1.5 kbar on the kinetics of the anation of $Co(NH_3)_5OH_2^{3+}$ by Cl^- and SO_4^{2-}, $Rh(NH_3)_5OH_2^{3+}$ by Cl^-, and $Cr(NH_3)_5OH_2^{3+}$ by NCS^- in acidic aqueous solution. Other research has included the uncatalyzed *cis* to *trans* isomerization of $PtX(C_6H_5)(PEt_3)_2$ (X = Cl,Br,I) in methanol. Activation volumes and kinetic data have been obtained which support a mechanism involving a rapid pre-equilibration step to form a solvent-containing species, *cis* - $Pt(sol)(C_6H_5)(PEt_3)_2$, followed by a rate-determining isomerization.

A high-pressure, stopped-flow instrument has been used to measure volumes of activation and to construct a reaction volume profile for the decarboxylation reaction of $Co(en)_2CO_3^+$. An OMA Type II rapid-scan spectrophotometer was coupled to a Durham model 110 stopped-flow system for these studies. This instrument has a dead time of 20 ms and uses fiber optics to determine the transmittance of the solution.

Finally, these groups are constructing a high-pressure probe for NMR measurements in order to study the kinetics of fast exchange reactions. A Varian multinuclear probe is being used and they expect to complete the construction very shortly.

In summary, I found many interesting chemical problems under investigation at this institute. With an expert research staff and superb high-pressure facilities, we can look forward to major contributions to the understanding of various chemical processes.
(A. Paul Schaap)

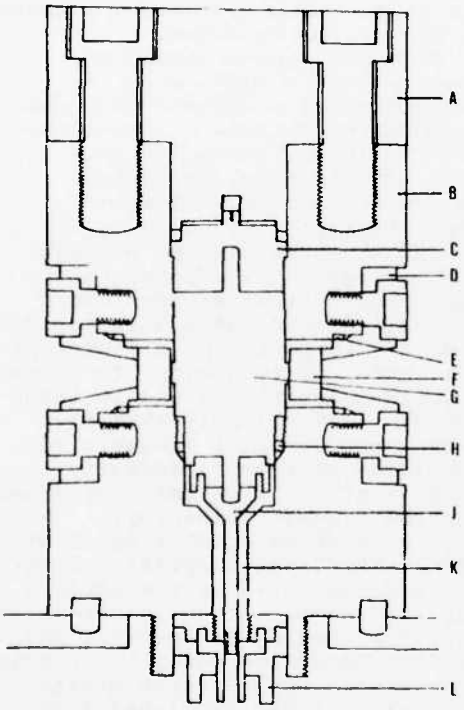


Figure 1. High pressure vessel
A vessel lid
B vessel body
C steel piston
D window support
E A- and O-ring
F saphire window
G space for T-jump cell (Figure 2)
H A- and O-ring
J steel high voltage connector
K insulation material
L high voltage plug

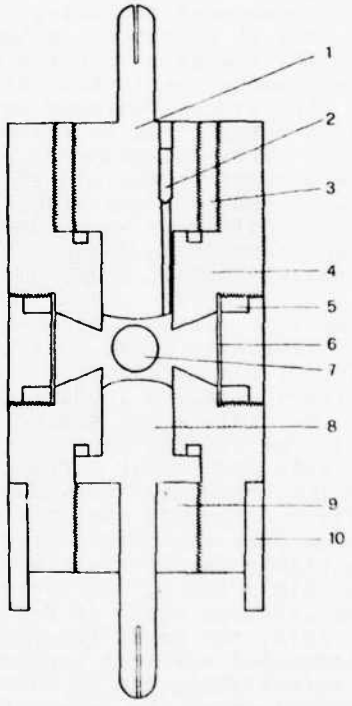


Figure 2. T-jump cell
1 upper electrode ⊕
2 de-aeration hole
3 electrode thread support
4 Kel-F cell body
5 membrane support
6 teflon membrane
7 optical window
8 lower electrode ⊖
9 threaded bolt
10 support ring

COMPUTER SCIENCE

DISTRIBUTED COMPUTING SYSTEMS (DCS) RESEARCH PROGRAM IN THE UK

Introduction

Parallel processing, multiprocessing, and distributed systems are buzzwords that have been humming merrily in the computer science community for some years. The basic conception is appealing enough: a collection of processing resources operating under hierarchical control. In such a system, the user specifies what is to be done, not which processing element will do it. One can hope for greater efficiency, flexibility, and reliability, as hardware advances multiply the number of separate processing entities. Some basic problems remain, however, despite the advances that have been made in component technology. Among these are: a lack of theory, a lack of methodology for adequate resource management, and extremely costly hardware developments that proceed without sufficient consideration being given to the software implications. When "distributed processing" became current in the mid-1970's, was it more of the same old problems, posing under a different name, and furthered by an esoteric in-group? The UK Science Research Council (SRC) did not think so.

In June 1976, the SRC appointed a government-university panel to study what action, if any, was necessary to coordinate and direct research in distributed computing. To utilize the scarce R&D resources in the UK, the panel was requested to take particular account of the possibility of unnecessary duplication of effort. The way that the panel has proceeded over the intervening five years is a highly instructive case example in how "big science," or better, coordinated science, works in Britain. In October 1976, the panel recommended that a coordinated research program should be established, and it circulated a draft program among the relevant technical organizations. A 1-day workshop was held at Imperial College, London, in March 1977; and this meeting provided a forum for 32 participating organizations to communicate directly their views and proposals on the problems which were to be addressed. Agreement was reached on the goals, on the approach, and on many of the specific projects. A distributed computer science (DCS) program was then formulated and initiated by the SRC in the academic year 1977-78. It has been funded to a total of £2.5M ($5M), and the program is scheduled to end in 1984. There are now 41 distinct projects in the program, and a total of 53 grants have been awarded, with no single grant exceeding £250K.

Program Management

The objectives of the DCS program, as taken from the DCS 1980 Progress Report are:

> "The primary objectives of the program are to seek an understanding of the principles of Distributed Computing Systems and to establish the engineering techniques necessary to implement such systems effectively. In particular, this requires an understanding of the implications of parallelism in information-processing systems and storage, and devising means for taking advantage of this capability."

The more general objectives of the program may be described as follows:

> "(1) To achieve results of practical value to UK industry by directing research to a key area for the future.
> (2) To promote relevant computing-science research of high quality in a positive manner in academic departments by coordinating the efforts and achievements of individual research teams.
> (3) To ensure the best use of funds at a time of financial stringency."

To manage efficiently the diverse research tasks, a "management by peer judgement" approach was adopted by the SRC. The hope was that a coordinated approach would produce both a reasonable balance of SRC support, and a framework for the transfer of technology to government research laboratories and to industry. The SRC felt strongly that the DCS was one area in which academic research could be of help to industry, in the exploitation of recent developments in integrated circuit technology.

A DCS program management panel of about 10 distinguished computer-science academics was appointed by the SRC's computing and communication subcommittee. Unlike advisory boards in America, this panel had the immediate power to approve, and to terminate, DCS research grants. Panel members were not precluded from participating in DCS research, and some of them have been active researchers throughout the program. The SRC's Rutherford & Appleton Laboratories contracted to provide administrative and secretarial services to the panel, and also to handle the details of contracts and finances.

It was recognized that some coordinators would be required, to do everyday management and review. By American standards, however, a surprisingly small coordination staff was engaged. One full-time academic coordinator was appointed,

along with an industrial coordinator to work on a part-time liaison basis. Although the coordinators and the panel secretary are on the staff of Rutherford & Appleton Laboratories, they act as roving ambassadors for, and report directly to, the panel. However, these two coordinators are not allowed to make any financial, administrative, or technical decisions which may affect the direction of individual research projects. The industrial coordinator's job is to provide information and to foster interest leading to collaborative research programs by industry and other government organizations. The primary role of the academic coordinator is to promote liaison among research investigators and to eliminate duplication of efforts. Reviewing progress, disseminating information, and promoting communication and collaboration among the investigators are essential elements of his responsibility.

Research Areas

The DCS panel organized the program into five major research areas. These areas, and some of the major investigators involved are listed in ensuing paragraphs. Some of these projects will be described further in future *ESN* articles.

(1) Theory and Languages

The DCS domain does not yet have a universally accepted theoretical basis for further work on both language and system design. The fundamental problem is to establish a methodology for representing and analyzing complex asynchronous systems. Among the important projects designed to attack this problem are the following: (1) Prof. A.J.R.G. Milner (Univ. of Edinburgh) is attempting to use flow algebra for representing concurrent processing and for studying the fundamental problems associated with the formal definition of DCS; (2) Dr. P.E. Lauer (Univ. of Newcastle Upon Tyne) has developed the COSY (CO Current System) notation as a formalism to analyze parallel systems as a set of interconnected sequential events which activate their operations according to their process definitions; and (3) Dr. G.D. Plotkin (Univ. of Edinburgh) is investigating the feasibility of achieving a general, and tractable mathematical theory for the semantics of non-deterministic and concurrent processing.

In the software domain, concurrency within programming languages, and the constraints a language should place on concurrency to insure good programming practice are among the topics being investigated. Prof. C.A.R. Hoare (Oxford Univ.) is attempting to "bridge the gap between very-high-level abstract specifications and very-low-level bit-pushing protocols of microprocessors and cheap peripherals"; he is approaching this by formal software documentation and publication standards. D. Coleman and J.W. Hughes (Univ. of Manchester Inst. of Science and Technology) are investigating the techniques of programming by interconnecting networks of communication processes. W.W. Wadge (Univ. of Warwick) is studying the distributed implementation of a non-procedural language for data-flow schemata. Dr. M.R. Sleep (Univ. of East Anglia) is designing an instruction set for data-flow architecture, and is pursuing its application to "pure combinatory code" for distributed computing. Dr. D.A. Turner (Univ. of Kent) is adopting a suitable high-level language of the denotational class for data-flow machines. As can be seen from the topics, all these efforts emphasize formalism, and amenability to proof techniques.

(2) Resource Management

As stated in the introduction, resource management is an important problem area which has contributed to the failure of parallel-processing research efforts in the past. Such elements as the distribution of control, the allocation of logical and physical resources, and the scheduling of local and remote resources have added to the complexity of DCS. N.H. Shelness (Univ. of Edinburgh) has been working on a distributed domain model for systems with no shared memory; his model allows processes to "migrate" from one processor to another. In a correlative effort, Dr. K.H. Bennet (Keele Univ.) is investigating a distributed file store which is implemented as a set of migrating files, but which appears as a local file store to the user.

(3) Architecture

Existing architectures in various categories are being evaluated for their DCS implications. Shelness is using a 3-processor multicomputer test bed with no shared common memory for his architecture effectiveness studies. Prof. M.V. Wilkes and Dr. R.M. Nesdham (Cambridge Univ.) have developed a wide-band digital communication ring for interfacing with a number of processors, and their experience with the "Cambridge Ring" will influence future DCS systems. Prof. D. Aspinall (Univ. Manchester Inst. of Science and Tech.) is investigating the behaviors of a 16-processor shared-memory system.

Several groups are looking at non-von Neumann architectures. Dr. J.R. Gurd & Dr. I. Watson (Manchester Univ.) are building a ring-structured data-flow computer prototype. Dr. M.R. Sleep (Univ. of East Anglia) is performing a comparative study of data-flow architectures.

Dr. P.C. Treleaven (Univ. of Newcastle Upon Tyne) is investigating the computer and program organization of a tightly coupled multi-instruction-multi-data stream computing system.

Interface and communication protocols are important topics in DCS architecture. In this area, Prof. P.T. Kirstein (Univ. College, London) is expanding the X25 communication protocols in the context of large DCS networks. Across town, Dr. Y. Parker (Polytech. of Central London) is simulating different models of multi-microprocessor system interconnections.

(4) Operational Attributes

The major grant in this area is the one awarded to Prof. B. Randell (Univ. of Newcastle Upon Tyne) to study the reliability and integrity of DCS. His project concerns a system level design language, and the mechanisms for using such a language to express policies relating to the overall reliability of DCS, and to the integrity of global data moving around in it.

(5) Design, Implementation & Application

This area is one in which research and development is nearing the breadboard stage. Since the human interface will be a critical part of effective DCS, the SRC is taking steps to insure that the most recent display and control guidelines are utilized. Two grants to Queen Mary College, University of London, specifically address the office automation problem: DCS Requirements For Effective Man-Machine Interaction, directed by Prof. G.F. Coularis; and Display System For Effective Man-Machine Interaction, headed by I. Page. These efforts have been reported in a previous *ESN* article (*ESN* 35-2:61 [1981])

Extramural Research (EMR) and DCS Equipment Pool

In addition to computer resources made available to all DCS research teams by the SRC network among the universities and SRC institutes, DCS-specific common developments (EMR) and equipment pools have been procured and maintained by the Rutherford & Appleton Laboratories for the DCS program, to eliminate duplication of expenditure. EMR contracts provided the following items: PASCAL Plus Compiler For LSI-11, PASCAL Plus tools, and a UNIX-X25 network interface.

Equipment in the pool is loaned to investigators when authorized by the DCS panel. Approximately £400 K capital expenditure has been approved to date. The pool contains multiple sets of: LSI-11s; Cambridge ring equipment; modems, tape decks, and VDUs; RT-11 kits; PASCAL source-code kits; and UNIX licenses.

Summary Comments

1981 is the midpoint of the 6-year ad hoc DCS research program. The effort is tightly bounded, in both time and money. The total budget (approximately £3 M) is less than many single grants awarded by US government agencies on some of the same problems; and it is orders of magnitude lower than the total annual US government expenditure for similar research at various universities. From all appearances, the quality of British research has not suffered from the austere funding. It is not likely that additional funds will be approved under current UK government budgets. How can the UK accomplish so much, for so little? Perhaps there are several lessons that can be learned.

A key element of the success is the wisdom of highly competent "peer managers." The panel has competence; it has power; its decisions are widely respected and quickly implemented. There are no layers of people who must approve expenditures. The people making the decisions are obviously the most competent people in the country to make them, and so there is much mutual respect between the panel and the researchers doing the work. The continuous panel review of progress is another factor which helps to insure the high quality of research, and maximum utilization of funds within the austere budget. The roles of the technical coordinators make the American-style bureaucratic R&D administrator redundant. The open publication and rapid dissemination of research combined with the continuous panel-review process, not only has eliminated most duplication of effort, but also has ventilated the evaluation of all the work, in an atmosphere of trust and purposefulness.

In short, the DCS program has concentrated on theory, formalism, and a responsive scheme of resource management. The program has evaluated and experimented with architectures and languages using existing and pooled equipments. It has, wisely in this writer's view, left the costly development to a later industrial phase; in that phase the task of the industrial coordinator will be more demanding and decisions often will involve more money. The DCS project will finally prove its relevance when this research program is terminated in 1984, at which time it should transfer the academic-research results to an efficient set of industrial-development projects. Until then, the jury is still out!
(Y. S. Wu)

ENGINEERING

HF RADAR REMOTE SENSING AND OTHER RADIATING SYSTEMS RESEARCH AT THE UNIVERSITY OF BIRMINGHAM

The University of Birmingham is small as universities go; it has only about 9,500 students on its spacious campus just 2 miles from the city center; but it has a reputation for high quality research. In the Electrical and Electronic Engineering Department (EEED) which I visited, the intake is about 120 students per year, and at this time there are 26 full-time and 6 part-time graduate students who are working for their master's degree or doctorate. Interestingly, a graduate has the choice of obtaining the master's either by passing exams after taking courses, or by doing research leading to a thesis. The academic staff numbers about 50. Research contracts are unusually high, amounting to about $10M for the university as a whole and about $1M for EEED; these contracts come mainly from government sources and support many research fellowships. Less than a year ago, W.V. Burt described the department's research efforts in acoustics in these pages (*ESN* 34-9:419 [1980]).

The purpose of my visit was to see Prof. E.D.R. Shearmen, who heads the postgraduate school and the Radiocommunications and Radar Group. The research group works closely with RSRE (Royal Signals and Radar Establishment), and some staff members from each organization hold honorary appointments in the other. Shearmen's main interest is in HF Radar for remote sensing of the oceans and the detection of ships. He described his work in remote sensing of seastate, where he uses either the ground wave with vertical polarization for ranges up to 300 kilometers, or the skywave, reflected by the ionosphere, for ranges of 1,000 to 3,000 kilometers. Much of this work is carried out in cooperation with the Rutherford and Appleton Laboratories west of London, and it will be described by Shearmen at the International Conference on Electronics for Ocean Technology to be held at the University of Birmingham in September 1981.

A former LORAN transmitter site is used for the ground-wave investigations. The site is in Pembrokeshire on the west coast of Wales. The transmitted signal operates from about 2 MHz up. The antenna consists of an 8-element array on a 300-meter baseline. The inter-element spacing is less than $\lambda/4$ at 2 MHz, giving ambiguity-free radiation patterns to almost 4 MHz. The array is electronically steered with switched time-delay circuits which, in contrast to phaseshifters, give frequency-independent scanning. The receiving elements are unmatched loops, fed partly as loops and partly as monopoles which, in proper combination, can give a cardioid type of radiation response. The number of elements was about to be increased to 16 on the same baseline, with a central section of the array being most densely populated, an arrangement designed to extend the ambiguity-free frequency range for that portion. Various transmitter/receiver radiation-pattern combinations are possible using floodlight, omni-patterns, and multiple simultaneous directive receiving beams. Radar echoes from the ocean (gravity) waves can be detected, and the analysis gives details of existing seastate conditions. The radar has a wide dynamic range and great stability. The received signals are coherently processed with dwell times of 50-150 seconds, giving a frequency resolution of 0.02-0.007 Hz.

A smooth sea will not give any radar returns at all. The returns are due to those gravity waves that are separated by $\lambda/2$ in the direction of propagation as seen from the radar. This is Bragg scattering which, as Shearmen points out, sifts out, from the chaotic superposition of wind-driven gravity waves, those waves which have the proper spacing, $\lambda/2$, and travel towards or away from the radar. The frequency of this return is shifted by the Doppler effect. The frequency spectrum of the radar return will therefore show two lines, the "Bragg lines," corresponding to ocean waves traveling towards or away from the radar. A third line will be present, at the transmitted frequency, due to stationary ground targets, and may be used as a reference for the temporal variations of the sea returns.

A model is used to obtain the directional reradiation pattern of the gravity waves. This allows the ratio of the amplitudes of the Bragg lines to be interpreted so as to give the direction of the wind-driven waves and of the wind which, it is reasonably assumed, they follow fairly quickly. Experiments have shown that the wind directions can be measured in this way to within ±15 degrees.

Further information is available from the Bragg lines. The Doppler frequency shift was found not to be symmetric about the transmitted frequency, as had been expected. This turned out to be due to the bodily motion of the ocean water, that is, to surface currents.

Secondary effects are also present in the measurements due to the complicated nature of the sea returns, and are represented by the complicated details of the Doppler spectrum. An inversion of this spectrum is possible, giving indications of the various parameters, such as wave height and "corner reflectors," formed by orthogonally traveling gravity waves.

So far, all processing has been carried out at the university. Recently, however, microprocessors have become available which are capable of displaying the Doppler from all 150-sec. dwells in all 24 range gates (7.5 kilometers each). Processing at the site is now being planned, and there may be a data link to the university.

The HF Radar is also used by Shearmen for Doppler and range tracking of ships. For this, he uses wide transmitting beams to floodlight the area, and a multibeam receiving system. Ships have been successfully tracked to a distance exceeding 200 kilometers, which is a considerable increase over normal radar capabilities. A ship is tracked by following its Doppler line in the spectrum of the target return. This line normally lies between the sea-clutter-(Bragg) lines and is identifiable.

Skywaves using ionospheric propagation can provide remote sea-surface sensing for ranges of 1,000 to 3,000 kilometers. The measurements again use Doppler analysis, but they are rendered difficult because the ionosphere itself produces slowly varying amplitude changes and Doppler shifts. The effects are minimized by illuminating only a small area of the ionosphere which, in turn, calls for a narrow beam-width system. The installation for this project is in Wiltshire. It uses a directive antenna with 49 broad-band monopoles in front of a reflector curtain, giving a 4° beam-width at 15 MHz. Doppler spectra were obtained in 500-sec. periods, by incoherently adding 10 spectra, each of which had been derived in one 50-sec. coherent dwell.

The remote sensing results were compared with *in situ* measurements in a major international exercise, JASIN (Joint Air-Sea Interaction project), which was carried out in 1978, using 14 oceanographic vessels, various buoys, and aircraft in the Rockall Bank area of the North Atlantic. Excellent agreement was found with the Birmingham results.

Attempts were made by Shearman's group, as well as by groups in the US, to Doppler-track aircraft from or to at least the mid-Atlantic. Successful tracking would allow closer stacking of aircraft than the present 150-mile spacing at the same height. The attempts were not successful: aircraft echoes were as much as 50 dB below the sea-clutter.

Shearman feels that the end of the research phase is now being reached and plans, together with the Appleton Laboratories, to use on-line processing to generate maps of oceanographic data. The group is also completing a mobile ground-wave radar with on-line processing for deployment in various localities.

Shearmen introduced me to Dr. D.C. Cooper, who is also using high resolution techniques, but this time in the context of the detection of small targets in sea-clutter, using microwave frequencies. As data he uses sea-clutter from tapes obtained in Norway during a 1979 NATO exercise, with an X-band radar looking from a cliff down onto the ocean with low grazing angles (about 7.5 degrees). The radar gave a range resolution of about 5m. Cooper studies the time-displaced correlation of sea-clutter between different range-cells and in this way detects moving bodies of water, waves, or other moving patterns. He is trying different processing techniques to take out the moving clutter in order to detect small targets. He has had success with simulated data in this effort, and is about to try real signals.

Dr. Tom S.M. MacLean heads the electromagnetic group. The work of this group is mainly theoretical and tackles a surprising number of problems, normally resorting to experiments only to confirm a theory. MacLean was working on a model of symmetric electromagnetic radiators (for example, a dipole) containing active devices. Active radiators of this type have shown useful wide-band matching properties and have been analysed in the past using approximations, most prominently by the now-retired Prof. H.H. Meinke at the Technical University of Munich. MacLean claims that his work is more rigorous and general than previous efforts, and he expects to have results within a year. He is also interested in a number of small antenna problems and is studying small paraboloids (one to several λ in diameter) and their focusing properties, as well as similar small wire-paraboloids and their radiated fields. Further, he is investigating biological interactions with radiators at frequencies below 1 GHz. He is trying, in particular, to model the effects of the human carrier on a bodily mounted antenna, and to calculate the accompanying field strengths in the body. He plans actually to build an efficient, physically small, man-held antenna, probably using ferrite materials to increase its electrical size. (T.C. Cheston)

THE RADIATION LABORATORY OF THE UNIVERSITY OF NAPLES

A variety of EM radiation problems are being investigated by a group at the University of Naples. The group is headed by Prof. Giorgio Franceschetti, who was host for my visit; he is well known in the antenna community. In the US, he holds an adjunct professorship at UCLA and spends much time there. In Italy, he is also a member of the scientific committee involved in the long-range planning for STET, the Italian-government-controlled holding group that controls much of Italy's major electronic industry, including the Italian telephone company. Franceschetti previously taught at Naples' Naval University, and he has retained many ties there. In particular, most of the laboratories are there and are shared by both universities for most experimental work. The University of Naples has a total of about 50,000 students, with about 9,000 in engineering. The Electrical Engineering Department has about 1,000 students; they get a degree, approximately equivalent to a US master's degree, in about 5 years. A PhD course is planned to start next year. There is a teaching staff of about 15, including 3 full professors, and the staff spends as much of its time as possible doing research. The research work is funded from outside the university and comes mainly from the (Italian) National Research Council, the European Space Agency, and industry.

Biological effects of radiation were studied by a group under Dr. Guglielmo d'Ambrosio, who is an associate professor. The group developed a method for creating a microwave field that could be accurately measured and described. The field was generated in a large high-Q metal reverberation box, where it was "stirred" by means of large metal vanes on a fan that changed the standing-wave pattern as it rotated. Large volumes thus became available where the time-averaged field was uniformly distributed and where the biological samples could be observed *in vivo*, independent of their position. With this setup, both the incident and the absorbed power levels could be measured accurately. Different size boxes were also developed. The largest was a cube of 2 m per side, and a larger one (4 m per side) was being planned. Samples were kept 4 wavelengths away from the wall; this practice, it was claimed, kept the variation in field strength to less than 1/2 dB. The measured Q of the empty box was 62,000. An anechoic chamber was also available at the laboratory and was used for experiments involving direct irradiation from 3 to 18 GHz.

The biological work included studies of mealworms whose larvae and pupae were irradiated at 9.4 GHz in a stirred reverberation box, at 2.45 GHz in a stirred microwave oven, and in a capacitor at ELF and DC. The effects of radiation were assessed from the number of abnormal specimens emerging after the pupation period. No remarkable effects due to 50 Hz and DC exposure were found, but at microwave frequencies a considerable difference between CW and pulse energy effects was noted, and it was suggested that some rapid-recovery biological mechanism was operating in the interpulse periods.

In a combined research effort with the Department of Medical Genetics, d'Ambrosio now wants to see if evidence of damage can be found on the chromosome level which could affect subsequent generations, and could, perhaps, cause mutations. Other studies have been directed to the application of microwaves to soil to kill grubs, and to the irradiation of grain and stored food for better preservation. One investigation concerns the healing of bones; it explores the possible beneficial effects of exposure to very-low-frequency magnetic fields.

Franceschetti has special interest in a relatively new study of electromagnetic fields in nonlinear environments. For this he is attempting to solve Maxwell's equations for any medium. The applications include nonlinear loading of antennas; biological interactions which result from rectification with low-level fields, perhaps creating interfering DC levels; and small, but significant, side effects of very-high-power systems. The last item is directed at the SPS (Solar Power Satellite) project where enormous amounts of solar power are captured in space, transformed to microwave power and beamed to earth to very large fields of receiving and rectifying arrays. Franceschetti says that even if only very-low-level harmonics are generated, grating lobes may be created where the addition of harmonic power would be in phase and would reach dangerously high levels.

Prof. Ovidio M. Bucci has given much attention to large reflector antenna systems and has collaborated with Franceschetti in much of this work. He described to me his analysis of the effects of the rim of an antenna, and how beneficial results could be obtained by loading it properly. The work was both theoretical and experimental. Far-out side lobes of the radiation pattern could be reduced by appropriate dielectric loading of the rim. The technique is applicable to Cassegranian systems; improvements with properly loaded subreflectors are claimed from beyond perhaps the second

sidelobe. Reduction in crosspolarized radiation is also claimed to be possible. Bucci's calculations used GTD (Geometric Theory of Diffraction). An extension of this work led to shaping the edge with a lip or flange that could be bent backwards or forwards; this approach includes what is sometimes referred to as the "tunnel antenna" where the rim extends in a cylindrical form, usually absorber-lined, for the suppression of far-out sidelobes.

The team also has investigated the use of sampling theory in the calculation of the radiation response of large antennas; the results have been published. The method is to compute for roughly one direction per lobe and to reconstruct the complete radiation pattern using sampling theory. A substantial reduction in computer time is achieved over conventional physical optics methods. At the present time, efforts are under way to find an efficient way to describe a scattered field, and to extend the calculations so as to include antenna near-fields.

Though relatively small, Francescheiti's group in Naples has a very vigorous research program. In the last 5 years the group has published well over 60 papers, most of them being written in English. (T.C. Cheston)

SOME ELECTRICAL ENGINEERING R&D AT THE TECHNION, ISRAEL

A general introduction to the Technion, Israel's counterpart of M.I.T., is not necessary in this note. Over the years, the institution's environment and many of its research activities have been described rather extensively in *ESN* (lately in *ESN* 35-6:211, 35-7:259, 35-8:304, all 1981).

The Department of Electrical Engineering (EE), headed by Prof. Zvi Kohavi, is a significant part of the Technion. Its undergraduate population of about 1,200 accounts for 20-25% of the institute's total undergraduate student body. On the graduate-student level, the percentage of EEs is only about 15%, due in part to the existence of a separate Department of Computer Science. Notwithstanding that other department's existence, however, about 30% of the EE graduate students specialize (through research papers and/or thesis) in computer-related areas, both hardware and software. The remainder of the students can select from the full range of the fields of study offered by the department: electromagnetics and electro-optics, electronic devices, circuits and networks, control systems, energy conversion, medical electronics and bioengineering, and signal-processing methods for use in radar and communication systems.

Before discussing some of the research activities within the department, I should note one peculiar pedagogical aspect of the department's operations which Kohavi described. Nearly half of the faculty are "adjunct," that is, they are regular employees of nearby industrial or military R&D establishments who teach courses in the department (and may also act as thesis or other research advisers) on a part-time basis. On one hand, Kohavi defended this policy by maintaining that it was the only way the department could attract well-qualified and experienced researchers to guide the students. But, on the other hand, he remarked on the obvious limitations of these part-time arrangements, and he indicated that the department is actively recruiting in the US and elsewhere for candidates to occupy full-time senior faculty positions. (Incidentally, for a male faculty member who is an Israeli citizen, "full-time" has a somewhat different meaning than it has in most other countries. Annual military-reserve service obligations can cut deeply into the time available for meeting academic obligations. One case in point: a renowned faculty member indicated that he was satisfying his military service obligation by spending 2 days per week during that semester working at the Ministry of Defence as a technical consultant. Others may serve their annual "time" in more conventional assignments, for a few continuous weeks of *really* full-time service.)

My visits with members of the EE research faculty were necessarily limited; they covered only a few of many projects going on at the time. In the area of signal processing, two types of projects were discussed: bioengineering, and those that were related to communication theory. In regard to the former, Assoc. Prof. Gideon F. Inbar described some of his work: the classification of electrocardiograms, and experiments with electromyogram data.

The standard electrocardiogram is generated by a set of 12 signals, with each signal derived from a point on the body to which an electrode has been attached. In the recent past, all of these signals were preprocessed by the same algorithm (in its simplest form, a filter-amplifier-d'Arsonval movement pen-driver). Then the set of preprocessed signals was further processed in a pattern-recognition (PR) step. Classically, the PR "processing" was done visually by the

medical practitioner, using a pen recording of the signals, with the body points being monitored in time sequence as an electrode was moved from point to point on the patient's body. With the advent of inexpensive microprocessors, it is now feasible and economic to have a set of dedicated microprocessors (or a time-shared unit) operating in parallel on each of the 12 signals. On each channel, the system can then utilize an algorithm which is optimized for the particular signal picked up by that electrode, thereby improving the quality of the data being fed to the PR processor. Inbar and some of his students have analyzed the different signals and, using Karhunen-Loève expansions, have derived optimum sets of bases by which the individual signals may be characterized. In the current experimental phase, this processing is being performed by a large-scale computer, with the final classification—a normal or abnormal designation, coupled with some quantitative characteristics—being derived by a single microprocessor.

Electromyogram signals are related to muscle activity. They can be used to characterize muscle diseases; they can also serve to measure fatigue and thereby to classify the fatiguing characteristics of various activities. These capabilities prompted the Ministry of Labor to sponsor Inbar's work in this field. Previous work along these lines by the group was reported in *Biological Cybernetics* (Vol. 29, 1978). The current work, soon to be published, is a set of experiments which evaluate muscle responses under both normal and degraded operation of the muscle-to-brain data link, with and without various types of external feedback.

The experimental setup is one in which a participant is required to operate a lever, one end of which is connected to the shaft of a torque motor. The motor torque is programmable; the participant attempts to counterbalance the varying torque and to maintain a "target" angle which may be either fixed or slowly varying.

In the past, this experiment has been run with normal internal muscular feedback and with visual feedback through a cathode-ray tube (CRT) display. It has also been run with the internal muscular feedback loop degraded, using a method which "confuses" the internal receptors on the participant's arm muscle. These receptors act as transducers from the muscle to the nervous system; they send signals to the brain in accordance with muscular activity in their respective areas. But their capability to transmit muscle-related signals to the brain disappears (thereby opening the feedback loop) when the receptors are excited acoustically at audio frequency by a sine-wave signal above about 50 Hz. At the receptor, a 100 Hz signal with an amplitude of only about 1μ is sufficient to phase-lock the receptor's output to the audio excitation signal, thereby blocking other signals. The interference is applied to the arm through a skin-mounted miniature "loudspeaker."

The problem with the experiment, which had been run some time before my visit, was that the deterioration due to "defective" internal feedback was hardly measurable when visual feedback was provided through the CRT: visual feedback was simply *too* effective. The display, which indicated both the target position and the existing position of the lever, could be interpreted through the eye-brain link and could initiate effective muscle action no matter how badly the receptors were blocked. Inbar needed a *less* effective feedback channel and, together with one of his students, he was designing a tactile feedback system which would operate through an Opticon. The Opticon transducer was originally designed by bioengineering researchers at Stanford University. (This device is normally used in conjunction with a photoelectric reader to provide a blind user with a means by which normally printed—rather than braille-embossed—characters may be "read.") The output element of the Opticon, in the configuration that Inbar is using, consists of an array of needles mounted in a finger-hugging cradle. The 144 needles are arranged in 24 rows of 6 columns. Excitation, which results in vibration, may be provided independently to each of the needles. As Inbar plans to use it, the information provided by the experimental setup is fed to two exciters, each one controlling half of the columns in the array. One side is excited so that the vibrating row in those 3 columns corresponds to the target angle, while, in the other half, the row of 3 vibrating needles corresponds to the lever's angular position. Through this tactile feedback mechanism, the subject attempts to get all 6 columns vibrating in the same row. Experiments which had been performed at the time of my visit had exposed some equipment shortcomings, which Inbar and his co-workers were in the process of correcting. But he said that they had shown conclusively that the subject performs this task noticeably better if the *magnitudes* of the angles are "displayed,"

rather than the *error* being displayed explicitly. The surprise I expressed at this statement was countered by Inbar's comment that this effect had been noted by other researchers in other types of human-response studies. Frankly, I'm still surprised—but perhaps the opinion that an error-type display is "easier" to use (see *ESN* 35-6:311 [1981]), may *not* mean that it also leads to better performance for certain types of tasks.

The next discussion was held with Prof. Israel Bar-David. He has been interested in signal processing, detection, and modulation methods for use in military-communication systems. Three projects were described. The first was a study to improve the detection threshold characteristics in a pulsed-frequency modulation (PFM) system, particularly one operating with speech as its input signal. PFM operates by sampling the amplitude of the input signal at a suitable rate and, in accordance with the amplitude of the sample, by shifting and holding the transmitted frequency at a value fixed for the interval. The technique that Bar-David has been studying for threshold extension demodulation is one which calculates a likelihood function associated with the received frequency in each interval. With his technique, instead of simply interpolating between the frequencies associated with the maxima of the likelihood functions, he processes the data associated with the maximum value and several lower-valued "peaks" of each likelihood function. Using these data and a Viterbi-like decoder, he estimates the original waveform, making use of the fact that speech has correlated sample values in adjoining time slots. Computer simulations were run for systems which retained up to the 4 highest peak values per interval, and then estimated the overall waveform in the presence of a noisy background. At a modulation index of 8, these tests indicated approximately a 5-dB improvement in the detection threshold level (over the simple interpolation system) for the 4-peak algorithm. Bar-David built a hardware version which was much simpler than the simulated 4-peak system: it utilized only the 2 top peak values, thereby simplifying the search algorithm considerably. This system provided only a 2 dB improvement in the threshold level under the same modulation index condition. Bar-David said that he was trying to get support to build the more complicated 4-peaks/interval system for use in field tests, but so far had been unsuccessful in that attempt.

Bar-David's second project was one related to time-division multiple-access space-communication systems. The problem was one of operating in the presence of burst interference, for example, from radar signals emitted by a scanning antenna. An adaptive system was envisioned, one in which the characteristics of the interference are detected and analyzed; these data are then used to effect a "real-time" change in the encoding of the communication signals. This procedure, it is hoped, will allow the application of more efficient decoding techniques for processing the "interfered" signals. Bar-David did not give details on the modulation formats being considered; neither did he describe the quantitative improvements implied by the adaptive system. He is planning to present more specific information at a conference later this year.

Bar-David's third project was related to direction-finding. In particular, the study dealt with a system which derives the angle of arrival from measurements of the difference in the times of arrival (TOAD) of a narrow-band (speech-modulated) signal at a pair (or more) of receiving stations.

In a laboratory environment, with narrow-band FM transmissions in the VHF band, he quoted a TOAD measurement accuracy of 0.1 μsec, and sometimes better, at times down to 20 nsec. The Cramer-Rao bound on the error variance for such a system is inversely related to both the square of the signal bandwidth and the signal energy-to-noise intensity ratio. This implies that, for a given bandwidth, the error variance is limited by the integration time of the processor, assuming that the signal remains well-enough defined at the receivers during the processing interval. Distortion by either the transmission medium or the receivers will adversely affect the system's accuracy. Bar-David's contribution to the solution of this problem was to design a fast-acting phase-locked loop subsystem which reduces the effects of differential-phase variations in both the medium and the receivers. As was the case in the first project we discussed, he is attempting to secure support to perform a field test with this system, but as before, he has been unsuccessful in obtaining that support.

Next, I met with Prof. Jacob Ziv, who, besides being a renowned contributor to the field of information theory, is now vice-president of the Technion for academic affairs. He had been working on a rate-distortion theory for individual sequences, where the sequences are

nonparametric. His latest published work on that subject was in the March 1980 issue of *IEEE Trans. on Info. Theory*. His current research, which will probably be published later this year, extends that work and also extends a coding theorem published in 1973 by Slepian and Wolf. The Slepian-Wolf theorem dealt with pairs of correlated, stationary, parametric sequences which are decoded in pairs. In effect, Slepian and Wolf showed that, even if a transmitter does not know how the receiver has interpreted a particular received y-sequence (the so-called "side information" about the x-sequence), the system can be made to achieve the capacity, H(x|y), for the x-sequence. (Loosely speaking, H(x|y) is the uncertainty about x, given y.) Ziv extended this result to the nonparametric case of "individual" correlated sequences. He has shown that a code can be designed to provide the same capacity for any given pair of sequences, and a code can also be designed that is good for almost all pairs of sequences (from a set of acceptable sequences). Furthermore, he has devised an encoding technique to achieve that capacity for a pair of sequences, in those cases where the intersequence joint probability distribution is known. This source-coding theorem has also been extended to include channel effects for restricted types of channels. Through a converse theorem, the channel capacity has been shown to be equal to: $\log \alpha - H(n)$, where α is the size of the character alphabet and H(n) is the entropy of the sequence. Lastly, a random coding scheme was developed which allows the design to realize that capacity.

My visit also included short discussions on the optical-data-processing work done by Dr. Joseph Shamir (e.g., detection of errors in photomasks used in integrated-circuit fabrication); on computer communication network routing and protocol studies by Assoc. Prof. Adrian Segall; and on derivations by Prof. Moshe Zakai of bounds on the accuracy of estimates of the response of certain types of nonlinear dynamic systems, when being observed by a noisy measurement system.

My impressions of the quality of research, the facilities, and the staff of that part of the Technion which I visited serve to confirm the impressions gained by many other colleagues: it is all first rate. (Philip Fire)

MATERIAL SCIENCES

COMPOSITES V

The Royal Society has sponsored three special meetings on fibers and composite materials. The most recent of these was held in May 1978, and in the introduction to the published papers (*New Fibres and Their Composites*, W. Watt, B. Harris, and A. Ham, [Eds.], The Royal Society, London, 1980), W. Watt referred to the first conference held in 1963 as initiating considerable research in the United Kingdom on composites. Indeed, some of the most fundamental research on strong fibers, especially carbon fibers, has been conducted in UK university and industrial laboratories over the intervening years. The engineering science and the technical utilization of glass-reinforced composites (GRFP) and carbon reinforced composites (CFRP) have been done largely in the United States, but the bedrock of fundamental knowledge has been and continues to be built in England. In this, the last of a series of articles on composites, the author describes work at the University of Surrey, the University of Liverpool, the University of Bath, and the Fulmer Institute.

University of Surrey

Watt, who is at the University of Surrey in Guildford, south of London, can fairly be called the grandfather of graphite fiber and graphite-fiber composites. He was formerly the head of the Department of Metallurgy and Materials Technology, but he has resigned that post and now holds an Honorary Senior Research Fellow position. The present department head is Prof. M.B. Waldron. My host during a visit to Surrey was Prof. J.E. Bailey, who heads the materials technology portion of the department. Both Bailey and Watt have been active in research on CRFP and GFRP for more than a decade.

In recent years, Bailey and his associates have conducted an intensive study of the transverse cracking of both glass and carbon continuous-filament composites. Their work is very pertinent in view of the current practice in the aerospace industry of using the failure strain of simple cross-ply laminates to evaluate the matrix-dependent properties of composites. Bailey indicated that in their experimental research they like to keep the specimen geometry simple. Consequently, most of their testing has been done with 3-ply laminates; specifically a 0°/90°/0° configuration. As shown in figure 1, on page 308, this laminate has two outer plies with

the fibers oriented in the direction in which the load is applied (0° ply), and an inner laminate with the fibers oriented perpendicular to the applied load.

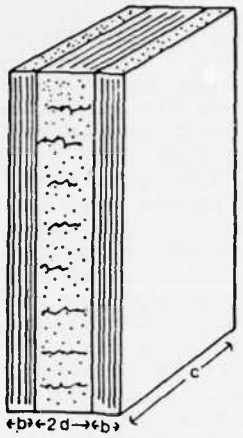


Figure 1

It has been known for some time that, in multi-ply laminates, failure is initiated by microcracking between the 90° lamella, despite the fact that the matrix resin has a higher strain to failure than the fiber (especially in the case of carbon fibers). This cracking occurs partly because of strain magnification due to the presence of the fibers, and partly to stress magnification (or poor bonding) at the resin/fiber interface. Although the laminate does not lose its integrity when 90° cracking occurs and it can sustain further load, the presence of these microcracks significantly reduces stiffness and presents paths through the laminate for water or other fluid agents. These cracks do not usually propagate through the 0° layer of fibers, but they can initiate interlaminar cracking between the 0° and 90° plies.

In their work, Bailey and his associates noted that the microcracks in the 90° ply have a more-or-less equidistant spacing (see figure). They suggest that, when a crack forms, there is an unloading of the ply for some distance above and below the crack. Consequently, another crack is unlikely to develop within this region of reduced stress. It was also observed that as the inner-ply thickness is decreased (the thickness of the outer ply is kept constant) there is a limiting thickness below which no 90° cracking occurs. This observation is of particular importance to laminate design, since it offers a means of avoiding the weaknesses caused by transverse microcracking. Bailey has developed a theoretical analysis that not only predicts the crack spacing but also, using a fracture-energy argument, predicts the limiting ply thickness below which no 90° microcracking occurs. This analysis produces some interesting conclusions; one would expect that an increase in resin strain to failure (ε_m) would increase the resistance to transverse cracking. However, the effect of ε_m and the effect of resin modulus (E_m) are coupled, and any increase in ε_m is usually associated with a decrease in E_m and reduced resistance to cracking. The Surrey group has found that CFRP and GFRP laminates have similar behaviors with respect to 90° cracking, but there are some interesting differences. Thermal stresses which can produce cracking develop higher strains in CFRP (in both 0° and 90° plies) than in GFRP. On the other hand, Poisson strains (strains transverse to the load direction) are higher in GFRP than in CFRP.

From both a fundamental and a technological point of view, it is of some interest to know where the 90° microcracking initiates: in the resin between fibers, or at the fiber/resin interface. Bailey and his coworkers are not entirely certain, but they have some microscopic evidence that these cracks begin at the interface.

University of Liverpool

At the University of Liverpool, the Department of Metallurgy and Materials Science is headed by Prof. D. Hull and Prof. B.L. Eyre. The department had been solely devoted to metallurgy until the mid-1970s when Hull, who had distinguished himself in physical metallurgy, sought to broaden the scope of the department to materials science in general. Hull began by studying the fracture of polystyrene, went on to investigate polymer crystallinity, and then began a major program on injection molding. In the work on injection molding, emphasis was placed on the effect that molding conditions produced on the microstructure and mechanical properties of the molded part. In molding polymers with short glass-fiber fillers, Hull concentrated on fiber orientation and the nucleation and microstructure of the matrix polymer on the fiber surface. One spinoff of this work came when Prof. M. Bevis left Liverpool and began to build another center for research and development on injection molding at Brunel University (*ESN* 34-5:228 [1980]).

Hull's interest in injection molding has diminished somewhat, although some work continues on reactive injection molding and hydrostatic extrusion. Emphasis in the department has turned to continuous fiber composites, especially filament-wound, glass-reinforced plastic

(GRP) pipe. This change in direction came about when Hull was dean of engineering and sought to interest engineers in composites. He wanted to focus on production rather than materials, and he realized that engineers can relate to pipe. At about the same time, problems were developing in the use of GRP pipe in the chemical industry. Unexpected failures and weeping of liquid through the pipe walls were part of the problem. Hull and people from Imperial Chemical Industries Ltd. began to press the UK Department of Industry to fund research to address these problems. Eventually a consortium of industry, academia, and government agencies was organized which, with strong support from the Polymer Engineering Directorate (PED) of the Science Research Council, developed a broadly based study of GRP materials. (*ESN* 33-5:189 [1979], 34-3:125, 34-7:330 [1980])

The present work at Liverpool on GRP pipe involves the hydrostatic testing of polyester-matrix glass-fiber, filament-wound pipe. A highly automated test facility applies a condition under which the axial stress is twice the hoop stress. The winding is helical, at 55°—the so-called ideal winding angle. At about 20% of the bursting pressure, liquid begins to appear on the outer walls of the cylinders, i.e., weeping occurs. Hull was able to show that, at this stress level, cracking of the resin transverse to the fiber results in interconnecting paths for the liquid to penetrate through the wall. In the pipes tested in this study, the matrix resin is sufficiently transparent that resin damage can be observed and appears as white streaks parallel to the fibers. Polished cross sections of the walls of cylinders stressed to the point of weeping show a network of interconnecting, transverse, and interlaminar cracking. Hull's microscopic investigations indicate that weeping is more generally associated with transverse cracks (cracks through the wound layers) than it is with interlaminar cracks between the layers. In a study of the effect of different winding angles on the onset of weeping, cylinders wound at 65° did not exhibit weeping until the hydrostatic pressure reached 75% of the bursting stress (compared to 25% for the 55° wound cylinders). This difference was attributed to the lower transverse stress in the 65° tubes.

In related work, Hull and Dr. P.J. Hogg have examined the effect of weak acids on the fracture of filament-wound hoops (NOL rings) subjected to compressive bending. In air or water, the fracture surface has a brushlike appearance due to the pullout of fibers. However, in the presence of the acid, the fracture surfaces are relatively free of fiber and appear flat, suggesting a "brittle" fracture. Hull suggests that in the absence of acid, the fibers break at weak points above or below the fracture plane, and, as the cracking proceeds, the fibers pull out and are distinctly visible on the fracture surface. In the presence of the acid, there is a corrosive action on the fiber at the fracture front, causing it to break in the plane of the crack. (However, at the UK National Engineering Laboratory (NEL) it has been found that this brittle fracture occurs in the field even in the absence of acids [*ESN* 34-7:330 (1980)]. Neither Hull nor the NEL workers have been able to simulate brittle fracture in the absence of acids.)

In subsequent work, Hull expects to determine whether increasing the strain capacity (toughness) of the resin or the resin/fiber interface can measurably delay the onset of weeping. Presently, he is developing an analysis to determine the resin-strain level necessary to inhibit transverse cracking.

Hull's contributions to physical metallurgy were largely related to the micromechanics of failure, and this is consistent with his present emphasis on the micromechanics of GRP failure. Indeed, he is writing a text on composite failure that combines laminate theory and failure micromechanisms; in Hull's opinion, this is an essential combination in order to understand composites properly.

Hull and Dr. Brian Seddon are working on energy absorbing composites with funding from the Ford Motor Company (UK) and the PED. The idea is to design structural tubes which collapse under high-speed axial compression in such a fashion that a large part of the mechanical energy is consumed as irreversible deformation. A 20-ton test machine operating at 2 μm/sec has been constructed, and Hull and Seddon are testing tubes fabricated by filament winding from short fiber reinforced composite, from the layup of resin impregnated continuous-fiber tapes (prepreg), and from the pultrusion of continuous fiber. Some of the reinforced material is needed to give the tubes the required stiffness and strength. However, the compressive failure of the composites tested so far has been too localized to absorb significant amounts of energy.

Other work at the University of Liverpool on composites includes a

look at the elastomeric interlayer between fiber and matrix, in an effort to increase fracture resistance at the glass/fiher interface. Dr. Colin Gatward is just beginning this project. Dr. A.G. Gibson has a PED/industry contract to look at various aspects of injection molding with short fiber reinforced plastics.

University of Bath

In the School of Materials Science, Prof. B. Harris and his staff have a very active program on the failure mechanisms of fiber-reinforced composites. They are currently investigating the fracture toughness of model composites and the measurement and interpretation of acoustic emission during loading of composite structures. The fracture specimen they are using is a double cantilever beam of polyester resin with fibers carefully placed at 1.2-cm intervals along the length of the beam and oriented perpendicular to, or at an angle ($\sim 70°$) to, the cracking direction. Each beam has about 6 fibers. Tests were conducted to determine the relative importance of fiber fracture, debonding, and pullout on fracture energy. The fihers were either freshly drawn from glass rods, surface treated with an organo functional silane adhesion promoter, or contaminated with skin oil by handling. The contaminated fibers were placed both perpendicular and at 70° to the crack direction. The result of these experiments indicated that the energy associated with fiber pullout is by far the most important mechanism contributing to fracture energy. This is consistent with Hull's observations that the acid environment causing fiher fracture obviates the pullout mechanism. However, Harris has analyzed his results using the theoretical development of A. Kelly (Bristol Univ., UK) and found that the theory could not adequately account for the magnitude of the measured fracture energy. He attrihutes the discrepancy to the fact that the fiber volume was unrealistically low in his test specimens, and that there were not enough data to be statistically significant.

The composite research group at Bath, in cooperation with Hull at Liverpool and Prof. F.J. Gill at the University of Manchester Institute of Science and Technology (UMIST), has undertaken a study of acoustic emission (AE) by composites under stress. The work aims to relate acoustic emission to the type and level of microdamage, and to use the results to diagnose the effect of multiaxial stress on composite structures. This study is funded by the PED and has immediate relevancy to work on GRP pipe.

Composites, like metals and ceramics, emit noise when a microcrack initiates or propagates, or when a fiber fractures. In studies of metals, triangulation techniques are used to detect the position of flaws. However, the use of AE for fiber-reinforced composites has not reached that level of sophistication. The problem is that, because so many different microfailure events occur at once throughout the loading spectrum, the counting of emission events is almost meaningles . Instead of pulse counts, Harris and his coworkers plan to obtain the AE amplitude spectrum and plots of the number of events whose amplitudes obtain a predetermined level as a function of that level. A simple statistical analysis (see A.A. Pollock, *Non-Destructive Testing*, 6, 284 [1973]) produced a single parameter that characterizes the overall noise emission. Any sudden change in the value of this parameter denotes a change in the failure mode; for instance, random micro cracking suddenly changes into large interlaminar cracking. This amplitude-spectrum approach to analyzing AE has one important feature: it can be used directly to compare laboratory tests and tests on structures of the same composite material. The analysis does not, *a priori*, relate micro events with acoustic emission. However, Harris is subjecting composite laminates to different types of stress—monotonic, creep, and cyclic loading—and where there is an abrupt change in the acoustic spectral parameters, the laminates will be examined to identify changes in the failure mode.

After establishing the relationships between emission amplitude and failure mechanisms in test plates and some substructural components, Harris will work with Hull at Liverpool on the AE analysis of multiaxially stressed GRP pipe. The cooperative work with Gill at UMIST involves acoustic-emission analysis during the cyclic-pressure loading of a GRP pressure vessel about 3 feet in diameter. A preliminary study in which AE was monitored from this structure was encouraging; a marked change in the amplitude spectra took place in the latter part of the loading program just prior to failure.

Fulmer Research Institute

The Fulmer Research Institute (FRI) Ltd. is located west of London in the town of Stoke Poges. The FRI is wholly owned by the British Institute of Physics. It is a contract research and engineering company with a clientele from industry and government in the UK and elsewhere. FRI is a nonprofit organization, so the money which would be realized as profit

goes to fund research or to help support the Institute of Physics. Associated with FRI and also owned by the Institute of Physics is Fulmer Technical Services Ltd., which does analytical and mechanical testing; the Yarsley Research Laboratory and the Yarsley Technical Center, which conduct R&D on polymer synthesis and processing respectively; and Fulmer Components Ltd., which fabricates special items, such as equipment for crystal growth and microelectronic devices.

At the FRI, I visited Drs. A.K. Green and W.H. Bowyer, who are involved in composite research and development. Bowyer leads a group that works on high-energy impact phenomena (mostly ballistic impact), composites, nondestructive testing, and powder metallurgy. Green is in charge of the composite work; he has a staff of 3-4 people, including professionals and students on various part-time, work-study programs. Bowyer directs the work on ballistic impact. Since the impact-resistant materials are primarily composite materials, Green's and Bowyer's interests frequently overlap.

Bowyer has developed a sophisticated apparatus to follow the dynamic response of bullets as they impact resistant materials. A promising material is a polyarylamide (Kevlar) polymer matrix composite. However, the mechanism of energy absorption is in question: how much energy is consumed in the interlaminar cleavage of the fabric plies, the pulverization of the material ahead of the bullet, and the drag imposed on the bullet by the surrounding material? The problem is complicated by the damage done to the material by the returning shockwave.

Green is concerned with bonding composites, patching and repair, and pultrusion. Specifically, he is working on the bonding of CFRP "top hat" stiffeners (Fig. 2), to the inner GRP hull of

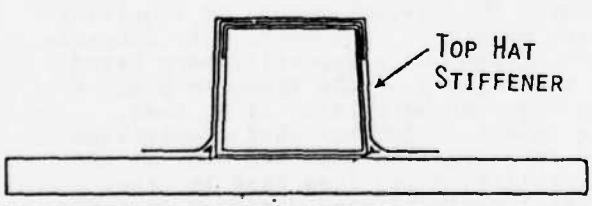


Figure 2

minesweepers (the UK has been a leader in the development of minesweepers with nonmagnetic-GRP hulls). At present, the stiffeners are attached using titanium bolts, which are costly and difficult to assemble, and which will not survive a mine explosion 5 yards from the hull. An alternative to mechanical fastening, of course, is adhesive bonding, which is potentially cheaper and stronger. The difficulty is that most adhesives are too brittle to resist cracking when the beam is subjected to bending stresses. Green has examined various methods to use adhesives in this application. A major problem is preventing the initiation of cracks from the "heel" of the foot where the stiffener is attached to the hull (see figure 2). Green uses 2-3 layers of glass cloth which are impregnated with the newly developed tough-acrylic resins. He also builds a GRP fillet to dissipate stress concentrations. The solution is simple and almost obvious. A practical difficulty is the development of workable layup techniques that require a minimum of labor.

Green is also involved in two projects to use composite patching material to repair damage to aircraft: damage to aluminum fuselage skins, and the repair of hydraulic pipe. In both cases, the patch need only be durable enough to get the aircraft home. A carbon-fiber, glass-fiber hybrid composite that has the same stiffness as aluminum aircraft skin has been developed at the Royal Aircraft Establishment, Farnborough. Green is developing techniques to bond this patch material to aircraft under front-line field conditions, where the primary problem is surface contamination.

Green's approach to repairing hydraulic lines is to form a tubular repair section by pultrusion of CFRP. The tubes have the necessary strength but are difficult to bond to broken steel tubing. Green has developed a method to combine adhesive bonding and pressure-fitted aluminum end caps to the CFRP tubes. Presently, he is determining the resistance of the CFRP II and the aluminum end caps to high-temperature environments, fatigue loads, and torsion loading.

The surge in applications of composite materials in recent years, especially in the aerospace industries, is resulting in the technology outstripping our fundamental understanding of these materials. To prevent this situation from becoming worse, there needs to be constant communication between the composites research community and the industry. The small sampling of research and development presented here gives some indication of the range and depth of the ongoing work in the UK. Although there is good communication between the UK and the US on the science and engineering of composites, we would be well advised to strengthen and broaden these interactions. (Willard D. Bascom)

Rapid Solidification Research in Switzerland, France and West Germany

On a recent trip to Europe, the author visited seven industrial and university laboratories which were involved with research related to rapid solidification, and in particular to amorphous metals. The establishments were: (1) Brown-Boveri and Co. Ltd, Baden, Switzerland; (2) Universität Basel, Switzerland; (3) Institut CERAC S.A., Ecublens, Switzerland; (4) Université Louis Pasteur, Strasbourg, France; (5) Vacuumschmelze GmbH, Hanau, West Germany; (6) Ruhr-Universität, Bochum, West Germany; and (7) Max-Planck Institut für Metallforschung, Stuttgart, West Germany.

At the impressively modern laboratory of Brown-Boveri, I saw Dr. R.S. Perkins, who is group leader in sintered materials, and his colleague, Dr. M. Fischer. Brown-Boveri produces equipment for electrical generation and distribution, transportation, (e.g., locomotives), electronics, and industrial processing. The laboratory has explored the use of amorphous alloys containing Ti or Zr as brazing foils for joining metals and ceramics. Amorphous foils are ductile and are easier to work with than conventional alloys in powder or composite form; they are also potentially much cheaper than the Ag-Cu-Ti alloys which are commercially available as homogeneous ductile foils. An example of such a brazing alloy is amorphous Cu-Ti containing 40 atomic percent Ti, which can be made directly as a ribbon by melt spinning. Other alloys could be based on the glass-forming Cu-Zr or Ni-Ti systems. These active brazing alloys do not require preliminary surface treatments such as metallizing. Also, since the Ti is almost a "universal solvent," the foils are applicable to a wide variety of ceramic and metal combinations: as one example, good bonding between Al_2O_3 and steel has been achieved with no preliminary surface preparation. Further, higher bonding strengths than those achievable using conventional materials have been demonstrated. These materials are being considered for joining electrodes to Brown-Boveri's new, low-ohmic, nonlinear PTC (positive temperature coefficient) resistors based on $(V,Cr)_2O_3$, which are an alternative to those based on $BaTiO_3$.

Brown-Boveri is also studying ion implantation, e.g., the implantation of N into iron. Properties of interest include wear, friction, corrosion, and fatigue. Another project seeks to develop new Ag-free or low-Ag materials for contacts. The new materials sought also should contain no Cd. In support of the ion implantation effort, a capability to measure the hardness of surface layers has been developed. Very light loads are used, such that the indentation depth can be varied from 300 A to 1 μm.

The physical metallurgy group, which I did not visit, is reportedly active in fracture mechanics and in superplastic forming, with emphasis on Al and Ti.

At the Institut für Physik der Universität Basel, Dr. H.V. Kunzi served as host for my visit to the research group of Prof. H.J. Guntherodt (who was away on travel). The staff also includes Prof. Rudin, Dr. Oelhafen, and 12 graduate students. A very broad range of characteristics of metallic glasses is being studied: preparation by melt spinning and by the 2-piston technique using levitation melting; structural studies via X-ray and neutron diffraction to determine the radial distribution function and phonon spectra; photoemission; elastic and anelastic mechanical behavior; the magnetostriction of alloys such as $Fe_{80}(Si,B)_{20}$ + rare earth, with particular attention to their applicability as force sensors; optical reflectivity; magnetic susceptibility; and Hall effect and conductivity. The laboratory facilities at Basel are exceptionally well organized and equipped. For example, a highly automated unit for melt spinning in a vacuum chamber has been constructed at a cost of 100,000 Swiss francs.

The Guntherodt group has been very active in cooperative applied research with industry. Such programs at the university are supported 50% by the government and 50% by the interested industry; though partly government supported, any results which are obtained can be company confidential. Such programs are very attractive to the Basel University investigators, since they provide the easiest method of acquiring major pieces of equipment. The cooperative efforts have generally been based on the ability of the group to prepare the required materials; after that, the amount of further characterization and investigation that was done at the university varied from case to case. Several projects were designed to evaluate rapidly solidified materials for (1) brazing foils wherein 1-inch-wide ribbons of Ti-containing alloys were prepared; (2) wear resistance applications of amorphous metal ribbons to evaluate their usefulness in weaving machines, marine motors, nuclear reactors, and other devices; (3) high-strength packing

materials; (4) concrete reinforcement, in particular as replacements for asbestos composites; (5) catalytic applications, e.g., in the the Ni & Pd systems; (6) hydrogen storage using Fe-Ti alloys; (7) suspension mechanisms in balances, to exploit the high elastic limit and good bending fatigue resistance of the alloys along with their "Invar" (i.e., temperature independent elastic modulus) characteristics; (8) corrosion protection; (9) implant materials having high biocompatability.

CERAC is an acronym for Central European Research - Atlas Copco. Atlas Copco is a billion-dollar company headquartered in Sweden; it specializes in compressed-air machinery and mining equipment. Institut CERAC in Ecublens has a technical staff consisting of 12 Ph.D.'s, 12 engineers and 12 technicians. Drs. Cooper, Morris, and Raybould were my hosts. CERAC has high-powered and sophisticated equipment for dynamic compaction; its equipment permits the rapid consolidation of powders using the very high pressures of shock waves. In such a process, surface melting of the individual powder particles can occur, but the total energy input can be controlled so as to limit the overall temperature rise of the bulk material. The interior of the particle can act as a heat sink for the heated surface, in effect quenching the heated fraction of the sample. Thus, one can consolidate metastable phases to full density. The short time of the consolidation event can prevent phase transformations or, in the event of partial surface melting, can permit the molten layer to requench to a metastable phase, for example, to a metallic glass, which is made initially by a rapid solidification process.

Two compressed-gas compaction machines produce the shock waves by means of a bursting metal diaphragm; a plastic punch is propelled against the encased powder to achieve compaction. A high-powered two-stage unit which literally looks like a cannon is employed for developmental work; a single-stage unit, considered a prototype for a possible production unit, is also being used. Typically, punch velocities of 500 to 2,000 m/sec are achieved, producing pressures in the range of 1 to 10 GPa. Projectile velocities as high as 4,500 m/sec already have been realized; it is expected that the projectile velocity can be increased by an additional 50% with this equipment. Some experience has been gained in the compaction of metastable alloys, in particular Al and Fe-Ni alloys; but this work has generally been done as a service for sponsoring companies, and the results are confidential. Some success has been achieved in compacting Metglas 2826, a commercially available amorphous alloy. In another project, a new PTFE-matrix composite was developed; the properties required in the material were good rubbing-wear resistance against cast iron, under dry conditions and with light loads.

Prof. J. Durand was my host at the Laboratoire de Structure Electronique des Solides, Université Louis Pasteur, Strasbourg. Amorphous alloys are made there by a piston-and-anvil technique; the setup produces small foils which are suitable for the studies being done. The overall goal of the research is to understand the local atomic arrangements within the amorphous structure. NMR and ESCA (photoemission) measurements are the principal techniques employed; electronic and magnetic behavior (e.g., superconductivity and saturation magnetization studies) are also of interest. Among the systems under intensive study are the Fe-Ni-B alloys; at issue is the origin of the change in the dependence of properties on composition at about 20 at % B. Binary metal alloys such as Ni-Zr are also being investigated. Beginning in October 1981, Durand will be at the Laboratoire Physique des Solides of the Université de Nancy.

Vacuumschmelze (VAC) is a subsidiary of Siemens and produces special metals for use in electric equipment. About two thirds of the company's output consists of magnetic alloys, in particular Permalloy, as well as permanent magnets (Sm-Co and the new workable Fe-Cr alloys) and insulated powders; the other third comprises special-purpose alloys for such applications as springs, superconductors, controlled-thermal-expansion materials, and so forth. In total, about 200 alloys are now being made.

The interest in Fe, Ni and/or Co-based metallic glasses at VAC stems from their magnetic softness, i.e., their low coercivity and low hysteresis loss. The R&D effort in this area is being supported in part by the Deutsches Forschungsgemeinschaft (similar to the US National Science Foundation); Krupp has had similar support. VAC is producing 25-mm-wide ribbon by melt-spinning; the product is sufficiently wide for the applications they are now pursuing.

There are many potential applications, and they include use as the cores of 400 Hz power transformers in aircraft or ships. A 20% increase in maximum power output, for given transformer dimensions, has been demonstrated by using 0.035-mm-thick $Fe_{81}B_{13.5}Si_{3.5}C_2$ instead of 0.1-mm grain-oriented Si-Fe.

Or for the same power output, the weight and volume could he reduced proportionally, when compared to Si-Fe.

The amorphous alloys are also useful in switch-mode power supplies which operate at very high frequencies, e.g., 20 to 100 kHz. The hysteresis losses of the amorphous alloys in the power transformers have been shown to he lower than those for a Mn-Zn ferrite below 160 kHz, and lower than those found at 1000 kHz for selected Fe-base and Co-hase alloys. Significantly, the losses in the amorphous metals are essentially those predicted from calculated eddy-current losses at, say, 50 kHz, so that no anomalous excess losses occur. The amorphous alloys, especially the Fe-Ni based compositions annealed to have a square loop, also offer good potential for use in the cores of associated transductors.

The magnetically soft amorphous alloys are promising materials for magnetic shielding applications. A zero magnetostriction alloy, $Co_{66}Fe_4(Mo, Si,B)_{30}$, was found to he three times more effective than Permalloy in one application. At VAC, the melt-spun amorphous alloys are produced directly as a thin ribhon; this form is directly useful for cahle shielding. Furthermore, the soft magnetic characteristics of the amorphous alloy, unlike crystalline alloys such as Permalloy, are not damaged readily hy the bending associated with normal handling.

VAC is developing force and displacement sensors hased on the magnetostrictive behavior of the amorphous metals. Selected amorphous alloys are also useful within magnetic heads, as in tape recorders; the high hardness of the alloys leads to good wear resistance, hence to long head life, and also to good electrical performance. Other applications could include magnetic springs comhining soft ferromagnetism (i.e., magnetic shielding) with a high spring constant; the combination of low coercivity and high-strength high-elastic limit of the amorphous alloys is not available from crystalline alloys. VAC has heen exploring the suitability of amorphous ribbons as bending springs; very good bending fatigue behavior has been ohserved in nonmagnetic Ni-Si-B alloys.

At Ruhr Universität in Bochum, there are a large numher of researches under way on the characteristics of amorphous metals; my overview of these efforts was received from Prof. V. Koster (now at Universität Dortmund) and Dr. Magdala Gronau. The following are just a few examples: magnetic property studies, i.e., saturation magnetization and spin wave stiffness; Mossbauer and NMR studies; superconductivity in evaporated La-Cu films; magnetic properties of evaporated $Sm_{10-30}Co_{70-90}$ alloys; Mosshauer studies at high pressures; phase stahility upon rapid solidification; crystallization hehavior of amorphous alloys; and mechanical properties of the amorphous alloy and the devitrified alloy.

An especially interesting project, being done in Prof. Honhogen's group by Herold and Koster, is directed to the crystallization behavior of amorphous (Fe,Ni)-B alloys. The researchers have concluded that crystallization of these glasses proceeds from a fixed number of nucleation sites which are quenched into the glass structure; that is, the nucleation event has already occurred, and annealing produces only crystal growth. The number of nucleation sites is strongly dependent on the quench rate used to form the glass, on the composition of the alloy, and possibly also on the initial melt temperature. Typically, the nuclei number about $10^{12}/m^3$.

At the Max-Planck-Institut für Metallforschung, Stuttgart, I saw Professors Predel and Steeb. Predel's group has concentrated on the thermodynamics of amorphous metals, in particular, Ca and Mg alloys. Dr. Sommer has been observing the enthalpy and free energy of the liquids which form glasses upon rapid solidification.

Steeb's researches have focused on structural studies. In his work, X-ray and neutron diffraction are used to determine the partial atomic distrihution functions. $Ni_{81}B_{19}$ alloys containing different Ni isotopes are heing prepared and analyzed hy neutron diffraction. Proper halancing of ^{62}Ni and ^{60}Ni produces an alloy in which only the B-B pairs contribute to coherent scattering; this gives a direct determination of the "metalloid-metalloid" distribution function, which is otherwise difficult to determine. Small-angle-scattering studies of $Fe_{80}B_{20}$ have also been carried out, and a rather strong small-angle scattering was observed. Since this scattering was independent of various applied magnetic fields, it was concluded to he from a source other than magnetic scattering. The scattering was found to he consistent with the presence of two distinct kinds of density fluctuations, each with characteristic dimensions of about 1.1 nm and 50 nm. (D.E. Polk, Office of Naval Research, Arlington)

OPERATIONS RESEARCH

UK RELIABILITY CONFERENCE

The Third National Reliability Conference took place at Birmingham, England, in April, 1981; it was sponsored by two UK organizations: the National Centre of Systems Reliability and the Institute of Quality Assurance. Of the nearly 300 people attending, about 90% were from the UK, with a sprinkling of participants from Western Europe, Japan, Israel, Australia, and the US. With 66 invited and contributed papers, the coverage was satisfactorily broad and corresponded rather well to the range of topics that are treated at the annual US Reliability and Maintainability Symposium. A fairly detailed treatment of the papers is being issued shortly as an ONRL Conference Report; this account gives a few highlights which may interest US readers of *ESN*.

To reliability professionals, actual long-term data on improved system functioning are often of great interest. R.C. Crombe and R.A. Merril (Taylor Instrument Co., US) showed that, for 21 system-years experience with 10 Mod III process control systems, reliability had improved by an order of magnitude. For instance, the average system delivered in 1979 had an early system life about 12 times better than did a similar system installed in 1975. These gains, as one might expect, were not achieved with any one approach, but utilized a package of design-enhancement and assurance programs.

Several authors reported on work that had to do with fault-tolerant systems. As an illustration, C.J. Wheaton (Safety and Reliability Directorate, UK) and D.M. Hunns (National Centre of Systems Reliability, UK) investigated the estimation of hazard rates for protective systems in which the component responses are used in an r-out-of-n configuration. Many alternative formulae were presented for various r-out-of-n combinations. Along these lines, J.M. Kontoleon (Univ. of Wollongong, Australia) described a method, and a computer program called SAFEGUARD, for calculating fail-to-safe and fail-to-danger probabilities.

In a session on the reliability of military systems, it appeared that some UK efforts are parallel to those in the US. There are new approaches to writing and enforcing procurement standards, as well as large data-bank projects for tabulating the defects in RAF and RN aircraft. Several speakers emphasized the lessons learned by British military commands during the 1970s; among these were the need for early life-cycle costing of systems, and the salutary effects of "forcing" reliability requirements on industry during the acquisition phases.

Much reliability engineering has been concentrated on electronic components and systems. In the Third Reliability Conference, data were presented from a great variety of settings: subsea oil wells, numerically controlled machine tools, pipes and pressure vessels, petroleum loading, chemical process control, natural gas distribution, ball bearings, commercial aircraft, advanced passenger trains, ships' engines, and many others. Some authors evaluated the statistical distributions which seemed most suitable to their particular data situations, with Weibull and log-normal often being judged as having the best fit to the data.

Nuclear-power reliability and control problems were considered from both technical and economic standpoints. A French paper by O. Muron, J.P. Signoret, and G. Cohen (ARMINES, France) concluded that the operate-shutdown decision must be made on the basis of both loss-of-production (economic) and risk (accident) criteria. These authors proposed a mathematical model which would optimize test and shutdown rules under the criteria. Also from France, C. leFloch and A. Villemeur (Electricité de France) examined the possibilty of rationalizing decisions when some components fail in the safety systems of pressurized-water-reactor (PWR) type nuclear plants. J.B. Fussell (Univ. of Tennessee) and D.J. Campbell (JBF Assoc., Inc., US) gave a state-of-the-art review of the US reliability analysis for nuclear-plants; these authors also provided a useful listing of computer programs now being used.

Among the other topics considered were the estimation of software reliability, legal aspects of product liability and warranty, and life-cycle costing. The complete conference proceedings were published in two volumes, which are available from the Institute of Quality Assurance, 54 Princes Gate, Exhibition Road, London SW7. Though this collection of papers somewhat overrepresents British data and the British official standpoint, it is probably the most up-to-date European source on reliability theory and application. (M.B. Kline, Naval Postgraduate School, Monterey, CA)

PHYSICS

POLYWATER AND BIRKBECK COLLEGE: AN EPILOGUE

Remember polywater - that strange substance that was reported to be a polymeric form of water produced by condensing ordinary water vapor onto silica surfaces? Its discoverer was Prof. B.V. Deryagin (Dept. of Surface Phenomena, Inst. of Physical Chemistry, Academy of Sciences of the USSR, Moscow), who was well known for other contributions to surface science. Deryagin had a reputation as an exceptionally talented experimentalist, but many of his theoretical ideas were highly controversial. He claimed that he observed surface forces acting over unusually long distances (thousands of angstroms); these claims were not generally accepted by some parts of the scientific community. Because of this skepticism towards his work, Deryagin's report alleging that he had discovered polywater, (which he called ortho water) was largely ignored in the West. His first publication on the subject appeared in the Russian literature in 1962. Despite the astounding nature of this "discovery," it was not until about 1968 that it began to create a stir in the West—and what a stir! The publicity began when Deryagin gave a paper at a Faraday society meeting in England in 1966; in that paper he discussed the various anomalous surface effects he had observed over the years, one of them being ortho water. Deryagin seemed to have done his homework; he had apparently performed all the necessary experiments to rule out contamination as an explanation for properties of ortho water: the high viscosity, the very low freezing point, and the observation that the material as a frozen solid was noncrystalline. Some of the British scientists hearing his presentation were impressed enough to try to repeat Deryagin's experiments. They faced a major problem in that Deryagin could only produce ortho water (also called anomalous water) by condensation in very narrow, freshly drawn silica capillaries. Thus the amount available for careful analysis was extremely limited. To characterize such minute quantities of material by such techniques as IR, spectroscopy, or X-ray crystallography, etc., it was necessary to utilize sophisticated equipment unavailable to Deryagin in Russia, but more available in England. For that reason, he was anxious to establish contacts with British scientists who could characterize his ortho water. One of these scientists, a personal friend of Deryagin, was Prof. J.D. Bernal of Birkbeck College (Univ. of London) who was well known for his work in X-ray crystallography. Bernal agreed to examine samples of ortho water supplied by Deryagin. Actually, Bernal was in ill health, and the study of this strange new substance fell to Dr. J.L. Finney at Birkbeck. Finney's results indeed suggested a structure that could not be attributed to ordinary water. These results, and IR spectra obtained in England and America, led to the expenditure of much time and effort to obtain polywater, and to explain theoretically its formation and anomalous properties.

Back in 1968, polywater was of great interest to many scientists. The primary sources of information in the US on the preparation and properties of polywater were an *ESN* article and several ONRL reports. As it turned out, the bulk of the evidence indicated that the unusual properties of ortho water were due to some contaminant. It is the author's opinion that silica was being leaked from the capillary walls to form a silica sol, but others attribute the phenomenon to contamination from other sources. As far as I know, Deryagin has never publicly retracted his original claims, but on the other hand, he has not published on the subject since 1970. Bernal died before the issue was resolved, and after 2 1/2 years of investigation, Finney and his coworkers concluded that polywater was the result of contamination by salts, vacuum oils, and other spurious materials (*Nature* 230 31 [1971]) which were unavoidable regardless of how carefully one performed the experiment. The full story of polywater has been related in detail in a very readable book by Dr. F. Frank (*Polywater*, MIT Press).

In the spring of 1980, I visited Finney and Dr. P. Barnes at Birkbeck college. We discussed polywater only briefly because there was much more exciting work in progress at Birkbeck, not only on the structure of "ordinary" water (which is not all that ordinary), but also on metals, proteins, and other substances, both amorphous and crystalline.

Birkbeck College is unusual in that it is fully devoted to part-time students. Its charter states explicitly that it is for students "engaged in earning their livelihood during the daytime." Classes are held between 6 p.m. and 9 p.m., and MA and MSc research is done in the evening or whenever the student can find time. Teaching at night can be hard

on the faculty, many of whom are part timers themselves, with day teaching or research positions elsewhere in London.

Finney and Barnes are in the Crystallography Department, which is headed by Prof. T.L. Blandell. The department has a faculty of 7, 3 of whom hold permanent positions. They are supported by a technical staff of 14, and there are 25 degree students. The department offers MSc courses in crystallography and biomolecular organization, and gives short (one-school-term) courses on protein structure and electron microscopy. It is trying to develop an MSc course on the conservation of artifacts; this degree program would run jointly with the Department of Archeology. The Crystallography Department would provide the materials science input to such a course. PhD degrees in crystallography and related fields are also offered by the department, but these advanced degrees are granted by the University of London.

Finney and Barnes are pursuing work that is a strong mix of theory and experiment. They have been developing models of: (1) the size and shape of single particles, (2) structure in randomly packed particles, (3) the dynamic structure of water, (4) the structure of the different crystalline forms of ice, (5) the structure at melt/solid interfaces, (6) the structure models of non-crystal material (notably amorphous metals and alloys), and (7) the structure of protein crystals. All of these models involve statistical methods such as pair-wise summation, random-walk theory, and various distribution functions. Consequently, much use is made of computer computation and computer graphics. At the time of my visit, Finney and his coworkers were debugging a three-dimensional graphic system that allows direct comparison of the X-ray diffraction pattern results with their 3-D models.

The philosphy underlying Birkbeck's approach to the modeling and analysis of structure is an outgrowth of Bernal's views and philosophy. Stated simply (but incompletely), these researchers are not trying to develop a structure relative to an external set of axes or by pair-wise addition. Instead, reference is given to a single molecule or particle, and the polyhedral structure which results is dictated by introducting the appropriate interparticle distances and forces. Then, polarizing interactions are considered to establish the three-dimensional structure. This approach allows dynamic effects to be considered, and also makes it easier to deal with glasses and liquids.

Judging from the prodigious amount of work that has been produced by the group at Birkbeck over the past decade, their approach has been fruitful. This is reflected in the fact that the laboratory they are operating has developed into one of the principal crystallography laboratories in the world. (Willard D. Bascom, Hercules, Inc., Magna, UT)

FROM CRYOGENICS TO QUARKS IN GENOA

The University of Genoa, founded in 1471, is a state-supported school under the jurisdiction of the ministry of public instruction. The university is financially supported by the government but is administered by its own board and academic senate. With an enrollment of about 25,000 students, it is medium in size for Italy (the Univ. of Rome has more than 100,000 students). Few new Italian universities have been built since WW II, partly because of the long bureaucratic delays.

According to my host, Prof. C. Rizzuto, the Institute of Physics (equivalent to a physics department in the US) has three main groups: the structure of matter, nuclear physics, and biophysics (which is centered not at Genoa, but at Camogli, a seaside town about 30 miles to the east). The staff numbers approximately 120, of whom 20 are full professors, 60 are associate professors, and 30 are technicians. All the physics instruction at the university is carried out in the institute and consists primarily of service courses directed to three groups of students: engineering ($\sim$ 1500 pa), medical ($\sim$ 700 pa), and pharmaceutical ($\sim$ 300 pa).

Between 150 and 200 students begin the 4-year physics major every year. About 40 or 50 survive to graduation; almost all of these people leave the university to take positions in Italian industry, which has now begun to use physicists. In the north of Italy, three industries—electromechanical (power grid, generators, etc.), nuclear, and steel (which is becoming highly automated) employ large numbers of physicists.

Some students continue their studies past a first degree to obtain a doctoral degree which, according to Rizzuto, is approximately equivalent to the master's degree in the UK. A PhD degree is not granted by the institute because it is not specifically permitted to do so under Italian law. (Permission to grant the PhD was requested 20 years ago, but the government has never responded). In Italy, education beyond the doctorate

is provided by enrollment in a "Perfection School" through which graduate students can obtain the approximate equivalent of a PhD.

Of a total of 36 persons in the structure of matter group, 4, including Rizzuto, are professors. The group's name does not really reflect all its activities, since the fields of study include applied superconductivity, surface physics, atomic and molecular physics, mass spectrometry and gas chromatography (to detect trace pollutants), energy balances in small environments (such as an isolated valley), and theoretical physics.

Until recently, Rizzuto was active in cryogenics and metal physics (*J. Phys.* [Paris] 40 C5-337 [1979]); he was the local chairman of the Eighth International Cryogenic Engineering Conference and Exhibition held in June, 1980, at Genoa. He is chairman of the National Group of the Structure of Matter (GNSM) which acts to coordinate and finance research in this field for the National Research Council of Italy.

Applied superconductivity research is a high priority of the GNSM and the work is split into three areas: superconducting materials, superconducting machines, and Josephson devices. This work is spread among 10 different groups throughout Italy. A general description of cryogenics research in Italy was given in a recent article by Rizzuto (*Cryogenics* 19, 243 (1979]).

At the university, research on superconducting machinery is being carried out by the Faculty of Engineering, where measurements of fatigue and dielectric losses in insulating materials are now being extended downward from the liquid-nitrogen to the liquid-helium temperature range. Theoretical work on the configuration and behavior of superconducting windings in machines is also in progress.

The group headed by Rizzuto is studying several other areas: power dissipation in superconducting wires used in machinery (the problem is different from transmission lines in that the wires experience a small fluctuating magnetic field), and low-temperature thermal properties of electrical insulation used in the construction of superconducting machinery. Also being investigated is the circulation in superconducting machinery of supercritical ^{4}He; i.e., at temperatures above the critical temperature but below the superconducting transition temperature of the windings. Above the critical temperature for ^{4}He of Tc = 5.2K there is no distinction between the liquid and gas phases.

Commercial development and construction of superconducting machinery and magnets also take place in Genoa - at Ansaldo Societá Generale, a company which has strong ties with the government and whose personnel cooperate with academics at the university. An 80 kw superconducting homopolar DC machine was built and tested there in 1975. More recently, the firm has constructed large superconducting magnets (1.6 m ID x 3.5 m length with a maximum field of 1.9T) for use at CERN, and large rotating machinery (1 m diameter, 3,000 rpm or 50 Hz). One of the goals of the company is the commercial production of superconducting AC generators, and as part of this project a simulator for testing windings at over 5,000 g (corresponding to 50Hz) has been devised.

Some experiments on surface physics were described by Dr. V. Valbusa who had recently returned from a visit to the University of Waterloo, Ontario. Valbusa and Dr. F. Tonmasini have spent approximately 5 years constructing a molecular-beam surface-scattering experiment for gas-surface studies. The apparatus incorporates a supersonic nozzle source, the capability for tilt and rotation movements of the sample, and a rotatable quadrupole mass spectrometer to measure angular and time-of-flight distributions of the scattered particles. A complete description, including some results of scattering ^{20}Ne and ^{22}Ne from LiF, has been submitted to the *Journal of Vacuum Science and Technology*.

In the scattering of atoms from a surface, minima in the specular intensity can be observed. Known as selective adsorption, the effect is associated with the occurrence of bound states. Valbusa and his co-workers have recently measured the selective adsorption of molecular hydrogen and deuterium (*Surface Science* 93 515 [1980]) and atomic hydrogen (*J. Chemical Physics* 73 556 [1980]) on the surface of graphite to study the laterally averaged particle-surface interaction potential. From measurements of the scattering of H_2 and D_2 from the (0001) surface of a graphite crystal, they determined the bound-state spectrum of energy levels, and were able to estimate the potential well depth and range parameters of a modified Lennard-Jones-type potential to within 1% and the strength parameter (exponent) to within 5%. A simple Lennard-Jones potential (6,12) will only reproduce the energy spectrum for nonrealistic values of the parameters.

In work done in collaboration with others at Waterloo and as yet unpublished, the scattering of atomic hydrogen from

a layer of Xe adsorbed on a (0001) surface of a graphite crystal was measured. The resulting diffraction patterns show that the adsorbed Xe atoms occupy sites in register with the C atoms in the center of adjacent graphite hexagons, and therefore form a layered hexagonal lattice with spacing $\sqrt{3}$ times that of the C atoms. A realistic potential of the interaction of the atomic hydrogen with the surface was also determined.

Prof. F.G. Fumi, who held positions at Argonne National Laboratories and Northwestern University, is well known to many scientists in the United States. On leaving the US in 1967 to go back to Italy, he spent two years at the University of Palermo before finally returning to his native Genoa in 1969.

Tensor properties and symmetry have been among his continuing interests. Recently he and Dr. C. Ripamonti published a lengthy two-part paper on a new method of determining the effect of rotational symmetry on general tensors. (*Acta. Cryst.* 535-551 and 551-558 [1980]). The scheme is particulary useful for hexagonal and trigonal symmetries, for which Cartesian orthogonal frames which are purely permutative under the group operations do not exist. In these papers, Fumi and Ripamonti have listed the complete schemes of tensors up to rank 8.

Fumi is also collaborating with J. Friedel on the construction of potentials for ionic solids. In particular, the Van der Waals interactions and the deformation of ions upon going into the solid state are being considered. Fumi said that my old friend, D.W. Lynch (Iowa State Univ.), had obtained an improved set of Born-Mayer potentials and that he (Fumi) hoped to improve on these, via consideration of higher derivatives of the energy where the Van der Waals interaction is more important. Including the calculation of local field corrections, Fumi estimated that this project would occupy the rest of this year.

An interesting change of subject was provided by talks with Prof. G. Morpurgo, who (*Nuovo Cimento* 39 409 [1965]) has been engaged in some aspects of quark hunting since 1965. A recent review of the experimental situation (*Science* 211 1028 [1981]) details the positions of Morpurgo (who sees no evidence for free quarks) and W. Fairbank (who does). One difference between the experiments was that the group headed by Fairbank used superconducting, magnetically levitated Nb balls, while Morpurgo's group experimented first with graphite and later with steel.

In the past, disagreements between the two groups as to the accuracy and interpretation of these delicate experiments had led to some rather heated exchanges of letters to the editor of *Physics Today*. Morpurgo is most desirous that such a debate should not continue. He hopes to obtain some FeNb balls to continue his experiments. The size required is about that of those used in ultrafine ball-point pens, and Morpurgo is experiencing difficulties in locating a small-scale supplier. It is possible that free quarks have a special affinity for Nb. Morpurgo hopes to perform his experiment with the FeNb balls and then, if he sees no evidence for free quarks, he will be satisfied (that they do not exist).

The topics covered in my visit ranged from directly applied ones relating to power generation to others that are in the forefront of science. I was pleased to see such broad and intense activity in this university which was founded before my homeland was discovered. (John R. Neighbours)

A VISIT TO ISRAEL III - THE TECHNION

Located on Mount Carmel overlooking the older part of Haifa, the Technion - Israel Institute of Technology is the oldest university in Israel (it opened for instruction in 1924), and is the country's leading engineering institution. With 22 academic departments distributed through the Science, Engineering, and Medical Schools, the university has approximately 5,500 undergraduate and 2,500 graduate students and accounts for over 70% of the engineers in Israel. The electro-optics research activities taking place there were reported recently in an article by R. Hughes (*ESN* 33:10-433 [1979]). On this trip, my primary purpose was to visit scientists who were carrying out condensed-matter research.

Many of the buildings of the Technion have been donated; the Solid State Institute is housed in the The Maurice M. and Reuben P. Rosen Research Building, which was completed in 1973. Prof. R. Kalish, a native Israeli and the director of the institute, pointed out that the institute is not an academic organization. Members of the institute perform sponsored research there; but all are faculty members from academic departments, principally the Departments of Physics, Electrical Engineering, Material Science, and Chemistry. This diverse interdisciplinary group of approximately 70, including students and technicians, concentrates its research talents on the properties of electronic materials. Work at the institute differs from "normal" research in that it is supposed to be more applied; this is particularly so regarding devices.

Crystal-growth facilities include Bridgman and Czochralski setups and a recently constructed vapor-phase-epitaxy system. In mid-1980, a laboratory for the study of surfaces was started; it provides facilities for analysis by scanning electron microscope (SEM), secondary ion mass spectroscopy (SIMS), Auger electron spectroscopy, and electron spectroscopy for chemical analysis (ESCA), as well as by other methods.

One of Kalish's major interests is the implantation of ions into various host materials and the characterization of the resulting material. The institute has a 350-kv ion accelerator with a mass resolution of $\sim 10^{-3}$, with which some 40 different elements in either the +2 or +3 state can be implanted. The machine has all-electrostatic focusing and all voltages are referenced to the mains voltage, so that if fluctuations occur, the beam will not wander from the target. Communications to ground are via a fiber-optic link. One of the two ion beams is used for implanting microelectronic devices for use at the Technion and by local industries. The other beam is used in channeling and ion-beam-probing experiments and can be swept in parallel lines across the sample.

Frequently, after ions are implanted in a sample, a post-implantation annealing procedure is necessary in order to achieve the desired electrical characteristics. The processes seem to be complex and are not fully understood. In the past, Kalish, with various of his colleagues, has studied the laser annealing of PbSnTe implanted with In, and the annealing and intrinsic limitations of doping diamond by In implantation. More recently, he and his coworkers have studied Si implanted with Ge (*Radiat. Eff.* 46 31 [1980]) using Rutherford backscattering (RBS) of protons and transmission electron microscopy (TEM). Ideally, the study of Si implanted in Si would best clarify the processes of damage resulting from ion implantation and the subsequent annealing effects. This was not possible because of the unavoidable presence of N_2^+ ions in the Si beam which came from the ion source refractory material. Therefore Ge was used instead, to avoid this contamination.

The implantations were all carried out at low ion-beam fluxes in order to avoid the possibility of sample heating due to the beam. After the final implantation, the samples were annealed for 12 hours at 550°C in a dry nitrogen atmosphere. The results of both types of analysis (RBS and TEM) showed that, when implantation was performed on a hot (473 K) substrate followed by implantation on a cold (300 K) substrate, the annealing processes were essentially additive. In contrast, when the order of implantation was reversed, the second implantation (at the higher substrate temperature) caused some beam-induced annealing of the damage resulting from the first implantation. The result is that the total effect is similar to that which follows from a single implantation at the higher substrate temperature. It is concluded that if sample heating occurs during ion implantation, the overall damage will resemble that of a sample implanted at a higher temperature.

Along with Dr. G. Braunstein, also of the Technion, Kalish has recently reported (*Appl. Phys. Lett.* 38 416 [1981]) on the effects of implanting various ions (Li, C, P, Ge and Sb) in diamond heated to 1000°C. The authors find from RBS measurements that when the diamond is heated to this temperature, most of the radiation damage problem is obviated. That is, the problem of graphitization, which occurs when implanted diamond is annealed, can be avoided by hot implantation. An additional benefit of this technique is that many Li ions migrate to interstitial sites where they become available as electrically active donors.

Fluorinated amorphous Si has better thermal stability than hydrogenated amorphous Si (See *ESN* 34-9:449 [1980] and consequently may have great potential for usage as a low-cost solar-cell material. Production of these films is being studied under the direction of Prof. R. B. Weil. In cooperation with Prof. M. Wolf (Univ. of Pennsylvania) and others at the institute, Weil investigated the preparation of fluorinated amorphous Si films by chemical vapor deposition (CVD) from SiF_2 gas. The deposition system contained pure Si in a furnace ($\sim$1200°C) and a substrate maintained at a lower temperature (450 - 850°C). A fixed quantity of SiF_4 gas was introduced into the system and circulated by a pump. In the furnace, the gas combined with the hot pure Si to produce gaseous SiF_2, which, when it encountered the cooler substrate, entered into a reverse reaction to produce solid amorphous Si and gaseous SiF_4. Approximately 1% F is incorporated into the fluorinated amorphous Si, which has optical and electronic properties similar to those of amorphous Si prepared by CVD from silane. These results were accepted for publication in the *Journal of Applied Physics*.

Another method of preparation by CVD utilized pyrolytic decomposition. In this scheme, the SiF_2 gas leaving the furnace was cooled to near-room temperature before encountering the

heated substrate. Study of the deposition kinetics showed that the rate-limiting process was the conversion of SiF_4 gas to SiF_2 gas in the furnace, and that the deposition rate was proportional to the flow rate. The optical properties of these films also were determined te be similar to those of Si films prepared by CVD from silane. A report has been submitted by Weil and his coworkers for publication in the *Journal of the Electrochemical Society*.

Prof. K. Weiser is an immigrant who was born in Austria and came to Israel in 1974, after spending some years at the IBM laboratories in Yorktown Heights, New York. After 4 years as director of the institute, Weiser spent a sabbatical academic year at the US Naval Research Laboratory, where he worked on the calculation of the properties of doped PbTe compounds. Weiser assumed that the two p electrons of the Pb atoms are transferred to the Te atoms to complete the p shell, so that the model is that of an ionic lattice of Pb^{+2} and Te^{-2} ions. According to Weiser, this lattice model, in which the total energy is the sum of an attractive Madelung term resulting from long-range electrostatic forces and a closed-shell ion-ion interaction energy, is justified on the basis of other quantum mechanical and pseudopotential calculations. Weiser also argued on the basis of ionic sizes that doping of PbTe by Group III elements (Al, Ga, In, Tl), can only be substitutional at the Pb sites. Whether a particular dopant acts as a donor or as an acceptor, then, depends on the energy level that results when all three electrons are stripped from the doping atom, as opposed to that which results when only the electron is stripped from the doping atom. In addition to the energies mentioned above, Weiser also considered the distortion of the lattice around the substitutional dopant. According to the calculations, Tl and Ga will act as acceptors, In and Al will act as donors, and, with the exception of Al, the concentration of electrically inactive species will exceed that of the active ones. Full details can be found in a recent publication (*Phys. Rev. B* 23 2741 [1981]). Now back in Israel, Weiser expects to terminate his work on PbTe and PbSnTe soon and to return to research on amorphous Si, his previous area of expertise.

Some scientists in the Department of Physics were also visited. Prof. J. Genossar is interested in H_2 storage in Mg and Mg alloys. Because of their light weight, it has been suggested that these materials might possibly be used for energy storage in mobile systems. Pure Mg tends to oxidize and thereby prevent the incursion of H_2; alloys with Ni or Cu have better performance. For example, in the eutectic alloy $Mg/MgCu_2$, hydrogen gas can reduce the copper oxide so as to provide continually clean surfaces. A recent publication (*Scripta Metallurgica* 14 275 [1980]) contains references to the Cu alloy work as well as descriptions of measurements of the Kirkendall effect (movement of boundary markers) in Mg during hydriding. Genossar and his coworkers interpreted the movement of W marker wires under hydriding as unambiguous evidence that the H^- anion is the diffusing species in MgH_2.

Currently, Genossar is investigating the optical properties and electrical resistivity of Ni alloyed with Mg. After hydriding, the interesting compound Mg_2NiH_4, which has a phase transition at Tc = 240°C, is formed. Above Tc the metals are in the CaF_2 structure; below Tc the structure is as yet undetermined—it may be monoclinic. After a few cycles in which H_2 is combined with Mg_2Ni and then retrieved, the material turns to a fine powder, since the volume changes by almost 40% with the introduction of H_2.

Genossar is also carrying out dilatometer measurements using a capacitance pickup and bridge with a system sensitivity, at present, of 1 μm full scale. He hopes to improve the sensitivity later, but is currently measuring length changes in $RbAg_4I_5$, a cubic material which has unusual behavior in the 100-200 K region.

Prof. S. G. Lipson and his coworkers are investigating the optical properties of the atmosphere. Lipson noted that extreme propagation conditions, including an atmosphere heavily saturated with water, desert conditions, and dust storms, can all be experienced in Israel. His group has published (in *Infrared Phys.* 20 165 [1980]) the results of preliminary measurements of the atmospheric transmittance in the 2.8-14 μm range. Measurements were performed over a 14-km horizontal path and also over a shorter path of approximately 1 km, in order to calibrate the source. These data were recorded for propagation in three different environments: in an urban setting, over the sea with a "dry sea wind" (Red Sea), and over the sea with a "wet sea wind" (Mediterranean Sea where the fetch is much longer). The results differed, in the 2.8-5.5 μm range, with the predictions of the computer program LOWTRAN-4. Further, and as yet unpublished, measurements in the 4.3-5.5 μm range and over longer path lengths indicate that the prediction of transmittance

in this region by LOWTRAN-4 is too large and that the discrepancy between measurements and prediction is the result of, and dependent on, the water-vapor content of the atmosphere.

The group has also developed a portable, dual-channel, all-reflecting-optics spectroradiometer for measurements in the 0.7 to 14μm range. Resolution of the instrument is accomplished by means of 2 continuously variable filters which have a limit of between 1% and 4%, depending on the filters chosen. The dual feature consists of a dichroic beam splitter and two detectors. Radiation with wavelength greater than 6 μm is directed to one detector, that with lesser wavelength to the other. Modular construction allows the detectors to be removed and interchanged. Those that have been used are: liquid nitrogen cooled HgCdTe (6-15 μm) and InSb (2-5.6 μm), uncooled PbS (1-4 μm) and Si (0.4-1.1 μm), and a pyroelectric one that extended over the entire wavelength range. Measurements of the sky's radiance with this instrument (*Appl. Opt.* 19 838 [1980]) also show discrepancies with the predictions of LOWTRAN-4, because the computer program does not account for the energy scattered *into* a transmitted beam. An adjustment to the computer program is also included in the publication.

There is also a small research effort being made in the Department of Physics on the interaction of mm waves with plasmas. This research was initiated by Dr. J. Politch, who is now working for the Ministry of Defense, but who still continues as an advisor. Prof. J. Felsteiner, who had also been working with this group, is spending the current year on sabbatical leave at Bell Telephone Laboratories, Murray Hill, New Jersey. Prof. Ben-Alyeh and Mr. A. Rosenberg, PhD student, are continuing the effort which has so far resulted in reports on detection (*J. Phys. D: Appl. Phys.* 13 813 [1980]) and amplification (*Phys. Rev. Lett.* 45 1787 [1980]) of mm waves by means of their interaction with a glow discharge.

Ben-Alyeh estimates that another year of study will be needed to understand the basic phenomena, and he is preparing a lengthy article on the subject. He and Rosenberg hope to develop a new mm-wave amplifier device. (John R. Neighbours)

NEWS & NOTES

CHANGE OF COMMAND AT ONR LONDON

In a brief ceremony on 25 August, Captain Lewis B. Sykes, USN, relieved Captain Philip F. Gibber, USN, as Commanding Officer, Office of Naval Research Branch Office, London. Captain Sykes, whose last several assignments have been in the Office of the Chief of Naval Operations in Washington DC, has served on destroyers, minesweepers, and submarines. He formerly commanded the submarine *CUTLASS*. He has done graduate studies in oceanography and economics, and holds the degree of Master of Arts (in economics). In addition to his duties as Commanding Officer, ONR London, Captain Sykes intends to pursue his interests in undersea warfare, and in particular, mines and mine countermeasures.

Captain Gibber has reported to the Naval Air Systems Command in Washington, DC. We wish him every success in his new assignment.

ONRL STAFF CHANGES

We recently welcomed three new staff members to ONR London. Dr. Ronald L. Derr is the new liaison technologist. A specialist in missile propulsion, he comes from the Naval Weapons Center, China Lake, California, and will be at ONR London for a year. Lt. Comdr. Robert W. Booker is a military oceanographer. He was previously assigned to the Office of the Commander of Naval Forces, Southern Europe, in Naples. Lt. Robert L. Harrod, who recently completed the Air-Ocean Master's Program at the Naval Postgraduate School, will be at ONR London for several months. His eventual assignment will involve oceanography/ meteorology at the Danish Hydrographic and Oceanographic Office, Copenhagen. At the same time, we bade farewell and Godspeed to Comdr. Clayton H. Spikes, who has been assigned to the Naval Electronics Systems Command in Washington, DC.

IF YOU CAN PUT IT TOGETHER, YOU CAN TAKE IT APART

Yugoslavia is trying a unique method for teaching computer technology. The Yugoslavians have purchased several ME 29 computers from ICL of Britain. But the contract calls for one of the ME 29s to be fully assembled and tested in Britain, then taken apart and sent to

Yugoslavia in hundreds of pieces. Yugoslavian mechanics will then assemble and check out the entire system; this experience, presumably, will produce a deep familiarity with the system.

The idea is not entirely new in the computer domain. IBM often sends its field representatives "back to the factory," to learn a new device by helping to build it. At the Burroughs UK computer plants, a "hot staging" systems test procedure is employed. Separate units, such as central processor, disk storage, and operator display, are manufactured at widely separated factories; a set of the units is brought together at one place in Britain, tested as a system, and then broken down into units again for shipment to the customer. Neither the IBM nor Burroughs schemes, however, involve the total disassembly of the major computer system down to the smallest piece part, and then later assembly by the customer.

Yugoslavia is already using ME 29s for its television service; in a recent European athletics meet at Zagreb, the computer was programmed to predict the standings of the different participating countries. Its failure to predict the national rankings perfectly, according to informants, was due to the fact that two German runners "suffered a loss of form."

COMPUTER-MANAGED INSTRUCTION: A SMALL SURPRISE

One of the presumed benefits of computer-managed instruction (CMI) is that much more information than would otherwise be obtainable is available about the progress of each individual taking the course. The CMI system may, for example, print out a status summary every day for each local course manager; this document can show which lesson each student is working on, test scores on module quizzes, the rate of progress relative to other class members, and perhaps even a "projected graduation date" from the course. Take-overs, repeatedly failed modules, and hard spots can be flagged for the attention of both instructor and management. Objective testing can be done by means of scoring machines at the school site, with results flashed to the main CMI computer. And this means that technical test-item data are also routinely computed, and can be used for automatic construction of adaptive test sequences. Some of the computations are done on-line, such as the determination of which module a student should take next; other calculations are done off-line, such as test-item statistics. For one two-shift CMI school operation, the main computer is working nearly 23 hours each class day. Maintaining, updating, and distributing all this management information is often a major requirement of the CMI computing facilities, and long special programs must be written to accommodate the users. With enough money and effort, the information can indeed be supplied; right now, some CMI systems serve thousands of students and dozens of instructors every day, with the calculations coming from a single large computer in a distant location.

Another type of CMI management information relates to the scheduling of classes. Given the student input flow and constraints such as lab space and the number of qualified class and lab teachers available, the CMI master program can provide an "optimal" plan for utilizing the resources. The optimization is achieved through operations-research programming techniques; the more advanced models permit a manager to vary some of the input parameters, and thus to explore some of the "what-if" questions that plague a real-world training establishment. Clearly, such a planning model should be valuable to a school manager who has to juggle facilities, instructors, and students. And just as clearly, a large systems effort is required to make it all work.

A large training unit of the British Army learned about these and other CMI benefits, and after careful consideration a large computer was installed, a small staff of specialists was assigned to work up a practical operating system, and several elementary technical courses (e.g., basic electricity) were chosen as vehicles for the CMI development. To produce the requisite software, the CMI analysts first had to get clear answers to many questions about course content and student flow through the training system. In a great many cases, these questions had not been specifically addressed before, or at least they had not been looked at for a very long time. Among the interesting issues that were examined were just what behaviors were really required of the graduating students, how the lessons and tests were evaluated, what information items training managers really needed or wanted to run a course, and what the "problem" conditions were that the new system was supposed to improve. Sometimes "walk-throughs" of the new CMI scheme were conducted, to elucidate the issues and values involved, and to discover just what actions, if any, would result from the pieces of paper that moved through the system.

Then came the surprise: the searching analysis of the whole training operation, which was supposed to underlie the new CMI software effort, revealed that elaborate CMI outputs from a big central computer would not help the course managers very much, and would not provide significant cost savings or improvements in student quality. As it turned out, optimization of classroom space, which it had been thought might be a useful output, was really rather obvious, and there was, in fact, plenty of room; computerized selection of next units to teach and automatic construction of new achievement tests were not really valuable in this particular setting. There was indeed a requirement for a few small stand-alone computers, to be distributed around the training center for local users, and to be equipped with test-scoring modems and a few short programs. But most of the fancier CMI output turned out to be perhaps "nice to have," but nearly irrelevant. So the large computer was taken out and installed elsewhere. From all reports, the several scattered micros have been very useful, and any further computerization of the training center will proceed according to a stand-alone concept.

This case does not demonstrate that big centralized CMI is not worthwhile. What it does show, once again, is that a careful and critical attempt to structure a complex domain (in this instance, a training system), can be the key part of what is often perceived as a "computer installation." When enough of the analysis is done, and only then, should hardware procurement decisions be taken. One of the important secondary lessons from the case is the value of a "paper utilization" walkthrough; a great majority of the CMI reports which had originally been planned "for management information" did not really inform management.

COMPUTERIZED CREDIT INFORMATION

One of the unobtrusive but effective offshoots of the computer era is the credit-information system, which is used to confirm the status of good customers and to identify frauds and poor risks. Unquestionably, these big credit systems work. Technical problems concerning the electronic accuracy of data storage retrieval seem to have been solved; the hardware is so reliable that system and terminal outages are quite rare; with millions of entries in their data banks, the systems can display, within a few seconds, a rather complete financial history on each person. If you are a shopper, the system can "grade" you and suggest a cash limit that a store might reasonably risk on you . And everything is so fast that there has been a serious proposal for citizens of EEC countries to have a coded financial "page" in their passports. This identifying page could he read electronically, and compared with recent financial activity and status, as a person leaves the home country. Presumably, such arrangements could identify debt evaders and other people in financial difficulties, and perhap prevent their exodus.

There are big questions remaining, of course, about the completeness, accuracy, and timeliness of all those millions of entries in the data bank. Since all entries and interrogations are made by people, there are many opportunities for clerical errors. And there are the broad social and legal questions regarding access. Right now, thousands of semi-skilled clerical people gain entry to the files, simply by inserting some company code numbers from the leased terminal. These people may not, however, know just how the company analyzes all the data; and of course some attempts are made to provide safeguards, say against an entry clerk who could improve (or downgrade) the ratings of personal acquaintances.

The legal and humanistic arguments over privacy and confidentiality will not be settled for a long time; emotions often run high on these issues. Recently, however, some objective analyses have been done on errors in the basic data files. At Credit Data, Ltd., London, for example; thousands of people every year ask for a listing of personal credit information that the company has in its bank, concerning them. (British law guarantees the right to have this information.) In one recent set of over 6,000 requests, only 38 errors were found in the files. Since each of the requests involved the tabulation of several items of data, it seems likely that the chance of a sheer data bank error wrong entry is something less than one in a thousand. This is an encouraging result, and the number of plain mistakes is expected to be reduced further by tab verification, tightened definitions of "address," and by restricting the data to items that can be easily updated and perhaps cross-checked.

Though it is seldom cited in psychological textbooks, the credit-data enterprise is a gigantic and successful exercise in the predictability of behavior. With millions of indexed people and a small set of innocuous data items on each person, quite good predictions

can be made regarding payment behavior. These predictions, and the associated expected risks, can be used to set "cutoff" scores that are of great practical value. It must be admitted, however, that the psychology involved is quite superficial: the fact that people with telephones are more likely to pay their bills does not represent a great psychological insight. Perhaps the main lesson from the credit-data game is that, with a clear-cut and univerally accepted criteria, you can skim off a few easily measured variables and set up a useful prediction system. For large military organizations, it may be that the "entering cutoffs" are not set as rationally as they are in the credit-risk case, because the military performance criterion is not as clean and objective as is payment behavior.

Because of the confidentiality aspects, computerized credit-data systems are not on line in some European countries. Sweden, for instance, does not encourage the accumulation and sale of personal data on its citizens. Ironically, the Scandinavian countries have some of the best government-sponsored data banks in the world; but they use these files for health and social welfare statistical studies, and not for commercial purposes.

ONR COSPONSORED CONFERENCES

International Symposium on Hydrodynamics in Ocean Engineering, Trondheim, Norway, 24-28 August 1981.

Conference on Combinatorial Optimization, Stirling, UK, 24-28 August 1981.

4th International Symposium on the Chemistry of Novel Aromatic Compounds (ISNA 4) Jerusalem, Israel, 30 August-4 September 1981.

NATO Advanced Study Institute on "Static and Dynamic Properties of the Polymeric Solid State," Glasgow, UK, 6-18 September 1981.

Fifth National Quantum Electronics Meeting, Hull, UK, 23-25 September 1981.

EUROPEAN VISITORS TO THE US SUPPORTED BY ONR LONDON

Visitor	Affiliation	Navy Lab./Org. to be Visited
Mr. Brian M. Count	Marchwood Engineering Labs, Southampton, UK	Civil Engr. Lab., NCBC (19-20 Oct. 1981) FLENUMOCEANCEN, NEPRF, NPS (21-23 Oct. 1981)
Mr. Stewart L. Wells	Dept. of Electronic Engineering, Heriot-Watt Univ., Edinburgh, Scotland	NOSC (31 August-4 September 1981) ONR West, Scripps Inst. (8-11 September 1981)
Lt. Yehuda Agnon	Headquarters, Israeli Navy, Tel Aviv, Israel	COMNAVOCEANCOM, NAVOCEANO, NORDA, ONR, NRL, CNO (October - November 1981)
Prof. E.D.R. Shearman	Dept of Electronic & Electrical Engineering, Univ. of Birmingham, Birmingham, UK	NRL (18 August 1981)
Dr. Schmuel J. Merhav	Dept of Aeronautical Engineering, Technion Israel	ONR (early September 1981)
Dr. W.J. Feast	Dept of Chemistry, Univ. of Durham, Durham, UK	ONR, NRL (August 1981)

ONRL REPORTS

C-3-81 17th International Symposium on Applied Military Psychology, by Nicholas A. Bond, Jr.

The topic of the 17th International Applied Military Psychology Seminar was "Psychological Prediction and Measurement of Individual and Unit Effectiveness." Twenty-two papers and ensuing discussions are summarized under six headings: Selection, Critiques of Selection; Job Satisfaction; Long-term Effects of Stress; Women in the Military; and Projective Testing.

C-5-81 IVth International Conference on Electromagnetic Windows, by T. C. Cheston.

IVth International Conference on Electromagnetic Windows took place on 10-12 June 1981 near Toulon, France. Thirty-one papers were presented describing developments of radomes for aircraft, missiles, and ground-based stations for both microwave and IR applications. The papers are briefly summarized and some of the comments made during the discussion periods are reported.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